Appendix E
Horn Lake, Mississippi, Stop-and-Go GPS Survey

E-1. General

In geographical areas with minimal obstruction of the sky, such as farming areas, along levees and open roads, stop-and-go GPS surveying can be a very effective and efficient method of establishing 2D and/or 3D project control. Stop-and-go surveying can be used to establish horizontal control for topographic and hydrographic surveys as well as 3D ground control for photogrammetric surveys.

E-2. Project Description

This example survey was conducted by the Memphis District in the vicinity of Horn Lake, Mississippi, approximately 15 miles south of downtown Memphis, Tennessee. A diagram of the project area is shown in Figure E-1. The project consisted of establishing 3D positions on a total of 23 photo control points.

E-3. Planning Phase

An initial search was performed to locate existing NGRS and USACE horizontal and vertical control within a 10-km radius of the center of the project area. It is important to note that the marks chosen to be occupied by

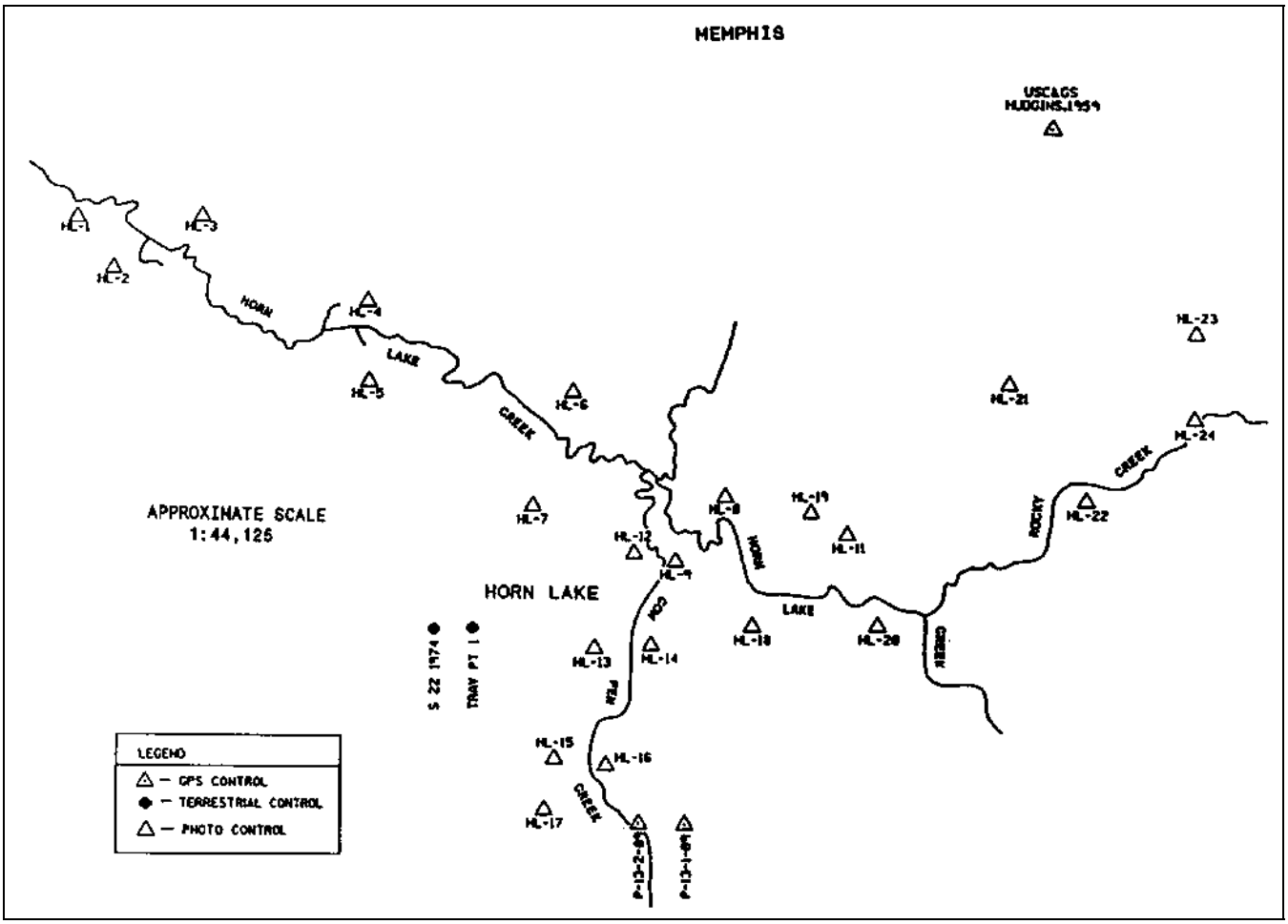

Figure E-1. Horn Lake Project diagram

the reference receiver(s) should be totally unobstructed. A momentary loss of lock (cycle slip) on one or more satellites by the reference receiver(s) could make it impossible to process some or all of the data obtained by the roving receiver(s).

a. Three NGRS horizontal and/or 3D control marks were recovered near the project area; however, due to obstructions at two of the sites, only the 3D mark USC&GS HUDGINS 1959 was suitable as a reference station. Preplanning analysis indicated a minimum of two reference stations were needed to economically obtain the required number of independent baseline measurements to each photo control point. Therefore, to meet this requirement, a pair of intervisible Type A monuments, as defined in EM 1110-1-1002, were installed near the southern limit of the project area with one of the sites (P-13-2-89) being totally free of obstructions greater than 15 degrees above the horizon. Initially, a static GPS survey was performed to establish horizontal positions on the two Type A monuments. A diagram of the initial horizontal control survey is shown in Figure E-2. Refer to the example surveys in Appendix D for details on performing a static horizontal control survey. Figure E-3 shows a partial output of the GEOLAB minimally constrained adjustment of the static baselines observed. A review of the GEOLAB adjustment output reveals the following:

(1) As shown the 2D and 1D station major semi-axis and minor semi-axis are at or less than the few-centimeter level.

(2) The 2D and 1D relative error ellipses between survey points are at or less than the few-centimeter level.

(3) The estimated variance factor in the statistics summary is low (close to a value of 1). Further analysis of the GEOLAB output in Figure E-3 indicates that the adjustment is very acceptable and that the adjusted positions of the two Type A monuments will be more than adequate for use as horizonal control for the stop-and-go survey. Reference stations USC&GS HUDGINS 1959 and P-13-2-89 were chosen because of their unobstructed view of the sky and also their location relative to the project area.

b. One NGRS vertical control mark and three USACE temporary benchmarks (TBM's) were recovered within the project area. The NGRS vertical control mark was 100 percent obstruction free and was thus included within the stop-and-go survey. However, due to obstructions at all three of the TBM's, it was decided not to include these marks within the GPS survey. Instead, differential levels were run from the TBM's to the nearest

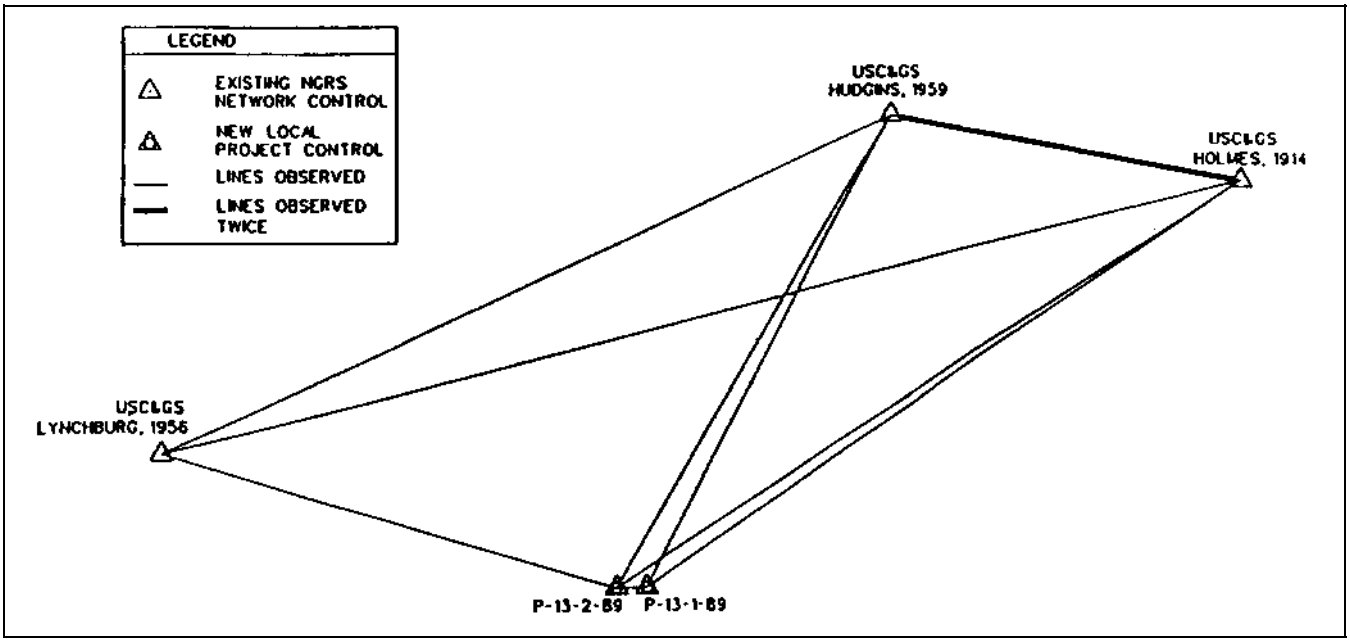

Figure E-2. Initial horizontal control survey

```
                U.S. ARMY CORPS OF ENGINEERS - MEMPHIS DISTRICT
                 GPS #7 - HORN LAKE CREEK AERIAL PHOTO CONTROL
A=  6378137.000 B=  6356752.314 XO=       0.000 YO=       0.000 ZO=       0.000
ELLIPSE:

2-D AND 1-D STATION CONFIDENCE REGIONS ( 95.000 %):

IDENT.     MAJOR SEMI-AXIS  MINOR SEMI-AXIS  AZ(MAJ)        VERTICAL
4098                0.0170           0.0116   119.60          0.0231
3095                0.0154           0.0092   118.54          0.0189
1096                0.0338           0.0136   116.46          0.0333
4097                0.0174           0.0123   118.20          0.0247

GeoLab - V1.91S, (C) 1985/86/87/88/89 BitWise Ideas Inc. [103208976]  Page   14


                U.S. ARMY CORPS OF ENGINEERS - MEMPHIS DISTRICT
                 GPS #7 - HORN LAKE CREEK AERIAL PHOTO CONTROL
A=  6378137.000 B=  6356752.314 XO=       0.000 YO=       0.000 ZO=       0.000
ELLIPSE:

2-D AND 1-D RELATIVE STATION CONFIDENCE REGIONS ( 95.000 %):

FROM     TO       MAJ.SEMI MIN.SEMI AZ(MAJ) VERTICAL SPATIAL DIST.     PRECISION
3094     1096       0.0338   0.0136  116.46   0.0333    13216.8982     2.559 PPM
3094     4097       0.0174   0.0123  118.20   0.0247     8561.2490     2.029 PPM
3094     4098       0.0170   0.0116  119.60   0.0231     8872.2474     1.912 PPM
3094     3095       0.0154   0.0092  118.54   0.0189     4254.4135     3.612 PPM
4098     1096       0.0309   0.0101  116.01   0.0274     5576.4108     5.539 PPM
4098     4097       0.0055   0.0045   84.37   0.0104      366.6958    14.958 PPM
4098     3095       0.0100   0.0085  135.51   0.0171     6444.1941     1.545 PPM
3095     1096       0.0316   0.0117  116.41   0.0300     9503.6545     3.321 PPM
3095     4097       0.0107   0.0095  125.96   0.0194     6257.9676     1.717 PPM

ELLIPSE successfully completed.
12:20:35 - Monday, July 10, 1989

GeoLab - V1.91S, (C) 1985/86/87/88/89 BitWise Ideas Inc. [103208976]  Page   15
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Figure E-3. GEOLAB adjustment output (Continued)

U.S. ARMY CORPS OF ENGINEERS - MEMPHIS DISTRICT
GPS #7 - HORN LAKE CREEK AERIAL PHOTO CONTROL

A= 6378137.000 B= 6356752.314 XO= 0.000 YO= 0.000 ZO= 0.000

RESID:

S T A T I S T I C S S U M M A R Y

Residual Critical Value Type	Tau Max
Residual Critical Value	3.1459
Convergence Criterion	0.001000
Final Iteration Counter Value	2
Confidence Level Used	95.0000
Number of Flagged Residuals	0
Estimated Variance Factor	1.3100
Number of Degrees of Freedom	27

Chi-Square Test on the Variance Factor:

8.1887e-001 < 1.0000 < 2.4271e+000 ?

THE TEST PASSES.

RESID successfully completed.

Figure E-3. (Concluded)

photo control point. The four points circled in Figure E-4 had an established orthometric height. These heights were used to control the vertical adjustment of the GPS observations. This will be discussed further under the section on adjustments.

c. The aerial photography was completed and photo control points were subsequently selected from observable physical features. The GPS survey party had to locate the points from the photos and monument each on the ground. Obstruction limits at each point were noted during monumentation. After all 23 points were established, further analysis indicated that three of the points, HL-2, HL-5, and HL-7 could not be occupied because of extensive obstructions or no vehicular access. Terrestrial traversing was performed to HL-2 and HL-5 using HL-1 and HL-3 as control and to HL-7 using S 22 1974 and Trav Pt 1 as control. The traverse computations were performed subsequent to the final constrained least squares adjustment of the baselines observed during the stop-and-go survey.

E-4. GPS Field Observations

Four SPS (or C/A) code GPS receivers, tracking the carrier phase, were used for the survey. When performing a stop-and-go survey, it is required to maintain lock on at least four satellites. It is recommended that observation-times be scheduled when at least five satellites are visible, so that if lock is lost on one satellite, the survey can continue. All GPS field observations, both static and stop-and-go, were recorded on 28 and 29 June 1989 (days 179 and 180). The reference receiver at HUDGINS was set up to continually record data each day and left unmanned due to its secure location. The reference receiver at P-13-2-89 had one operator monitoring it and there were two personnel per roving receiver: one to drive the vehicle and operate the receiver and the other to position the antenna over the mark. Communication between operators was by two-way radio.

a. The antennas at the reference stations were mounted on a tripod using an optical plummet tribrach with an 8-minute bulls-eye level. The antenna for each roving receiver was mounted on a fixed-height range pole with a 10-minute bulls-eye level supported by a bipod. The antenna, range pole, and bipod were secured to the vehicle by a removable mobile rack shown in Figure E-5. Figure E-6 shows the setup of the antenna, range pole and bipod.

b. A satellite visibility chart was plotted for day 179 and is shown in Figure E-7. Static measurements were recorded for the first two sessions and the data used to establish horizontal positions on the two Type A monuments. Refer to Figure E-2 for a graphical representation of the baselines observed during sessions 1 and 2. The remainder of the five-satellite window for day 179 was used to record stop-and-go data. The observation schedule developed for day 179 is shown in Figure E-8. The upper portion of the schedule includes the ID number, the name and the position (exact if known, scaled if not) for each station included within the survey. Note that the photo control points were assigned a 5000 series ID. Chapter 8 of this manual discusses recommended conventions for assigning station ID numbers. It recommends a 9000 series number for temporary 3D control. The bottom portion of the schedule includes the date and day of the year in which observations are to be recorded, where each receiver will be for each session, when to start and stop each session (local time), and which satellites to observe.

c. Stop-and-go observations were recorded during the third session on day 179 and during the entire five-satellite window on day 180. During the third session of day 179, both roving receivers were initialized to both of the reference receivers by recording static data for approximately one hour. This method is also referred to as occupying a known baseline, since after post-processing the static data and the data are accepted according to the criteria in this manual, the baseline becomes known. It is important to note that this method requires a sufficient amount of data be collected to ensure that the integer cycle ambiguities are resolved in the baseline solution. Once the integer cycle ambiguity is resolved for a satellite, it remains constant as long as lock is maintained. At the moment lock is lost on a satellite, its integer cycle ambiguity becomes an unknown value and thus again requires resolution. Initially resolving the ambiguities and maintaining lock on at least four satellites is the key to stop-and-go surveying. If lock is not maintained on at least four satellites during a survey, the ambiguities for at least four satellites will need to be resolved again. This can be done during a survey by returning to the last occupied point, which becomes a known baseline after postprocessing. If this method is not practical or desirable, the survey should be stopped at the point of losing lock on at least four satellites and a new survey started. The new survey may be initialized either by recording approximately an hour of static data at a point which has not already been occupied, or by recording a few minutes of data at a point which has been previously occupied. When using the second method, the integer cycle ambiguities for the baselines from both reference receivers to the

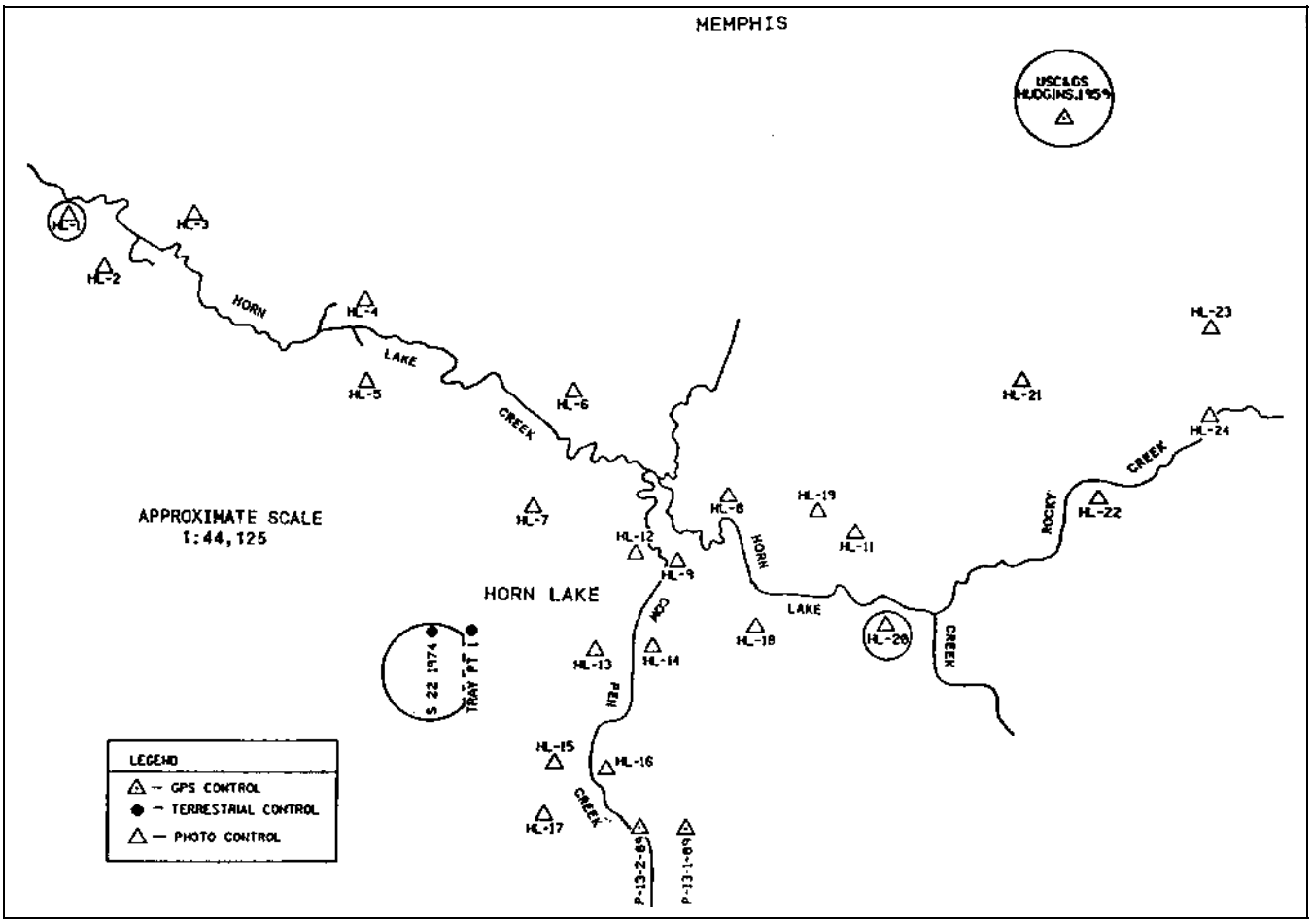


Figure E-4. Vertical project control

Figure E-5. Removable vehicle rack

Figure E-6. Antenna-range pole-bipod setup

point must have been resolved. Figures E-9 and E-10 show the baselines for which the integer cycle ambiguities were resolved by collecting static data for approximately one hour by roving receivers 1 and 2, respectively.

d. After initializing the stop-and-go survey, the rovers began to travel from point to point, collecting approximately 1.25 minutes of data at each point. This manual recommends data collection of at least 1.5 min at each point. Experience has shown this value should be used as a minimum and, depending on the length of the baselines observed and the accuracy required for the survey, observation times of up to 10 min may be necessary to ensure the desired results are obtained. A data logging sheet such as that shown in Chapter 8 was completed for each reference receiver. For each roving receiver, a stop-and-go field form as shown in Figure E-11 was completed. Figure E-12 shows a field form completed for roving receiver 1 on day 179. The paths taken by each of the rovers on days 179 and 180 can be graphically seen in Figures E-9 and/or E-10. The data collected for the initialization of the survey as well as the data collected at each subsequent point by rover 1 were recorded in one data file. It is recommended that static observations be recorded in a separate file from the stop-and-go data to conform to batch processing methods used in some manufacturer's software. This will be discussed further under the section on post-processing. Referring to Figure E-12, the following is a recommended scheme for recording the data such that a batch processing mode may be utilized.

(1) Start static survey at 22:04 occupying station 4097. Stop static survey at 23:00.

(2) After resetting the antenna over station 4097, start a stop-and-go survey and collect data at 4097 for approximately ten minutes.

(3) Travel to each subsequent point and collect data for at least 1.5 minutes.

(4) Upon losing lock travelling to station 5208, stop the stop-and-go survey.

(5) Continue to 5208, position antenna over mark and start a static survey at approximately 00:42.

(6) Stop the static survey at 01:45, which was very near the end of the four satellite window for day 179.

If additional time had been available in which five satellites were above 15 degrees, another stop-and-go survey could have been started and continued from 5208 to additional points subsequent to the static data collection.

E-5. Post-processing Stop-and-Go Data

At the end of each day's observations, all data were downloaded from the receivers to a portable 386 computer. All processing times quoted in this example are using a 386 computer with a math coprocessor with a 20-MHz clock processing speed. Using a computer with slower clock speeds will significantly increase processing time of all types of GPS data, not only stop-and-go. A review of all field data logging sheets for completeness and correctness was performed after downloading the data. Trimble's Trimvec-Plus survey software was used for all post-processing in this case.

a. First, all data collected in the static survey mode were post-processed and the quality of the solutions reviewed. Processed baselines from sessions 1 and 2 of day 179 were used to create a network in GEOLAB and adjusted separately from the photo control. The results of this adjustment have been discussed in paragraph E-3. Since the stop-and-go survey was initialized with known baselines, the dX, dY, and dZ values for the known baselines were required prior to processing the stop-and-go data. These values were obtained from the solution output of the static observations. Figures E-13 and E-14 show the solution summaries for the baselines from each of the reference receivers to roving receiver 1. Notice that the integers were found for each baseline and that the

Table of Azimuth, Elevation and Time for HORNLAKE

Date : 28 Jun 1989
Time : 15:00 -> 21:00
Cut-off Elevation : 12°

Latitude : 34° 58' 00" N
Longitude : 90° 02' 00" W
Zone : - 5:00

Time	Satellite 3		Satellite 6		Satellite 8		Satellite 9		Satellite 11	
	AZ	EL	AZ	EL	AZ	EL	AZ	EL	AZ	EL
15:00	--	--	331°	43°	230°	67°	--	--	221°	27°
15:10	--	--	331°	48°	241°	71°	--	--	225°	31°
15:20	--	--	331°	53°	257°	74°	--	--	229°	35°
15:30	--	--	331°	58°	278°	76°	--	--	233°	39°
15:40	--	--	329°	63°	302°	76°	327°	14°	239°	42°
15:50	--	--	325°	68°	322°	74°	327°	19°	244°	46°
16:00	--	--	317°	73°	337°	71°	327°	23°	251°	49°
16:10	--	--	303°	77°	348°	67°	327°	28°	258°	52°
16:20	--	--	277°	79°	357°	64°	326°	32°	265°	54°
16:30	--	--	246°	79°	4°	60°	324°	37°	274°	56°
16:40	--	--	224°	75°	10°	56°	321°	41°	283°	58°
16:50	--	--	212°	71°	15°	52°	318°	45°	293°	59°
17:00	--	--	205°	66°	20°	49°	313°	49°	303°	59°
17:10	--	--	201°	60°	25°	45°	306°	53°	313°	59°
17:20	--	--	199°	55°	29°	42°	299°	56°	322°	59°
17:30	--	--	197°	49°	33°	38°	289°	57°	332°	59°
17:40	--	--	195°	44°	37°	35°	279°	58°	341°	58°
17:50	--	--	194°	38°	42°	32°	269°	58°	350°	56°
18:00	--	--	193°	33°	46°	29°	259°	56°	358°	55°
18:10	--	--	192°	28°	50°	26°	251°	54°	6°	53°
18:20	--	--	192°	23°	54°	23°	243°	50°	13°	52°
18:30	--	--	191°	18°	58°	21°	237°	47°	20°	50°
18:40	--	--	190°	14°	62°	18°	232°	42°	27°	48°
18:50	--	--	--	--	66°	16°	228°	38°	33°	46°
19:00	284°	14°	--	--	70°	13°	225°	34°	39°	44°
19:10	288°	16°	--	--	--	--	221°	29°	46°	42°
19:20	293°	18°	--	--	--	--	219°	25°	51°	40°
19:30	297°	21°	--	--	--	--	216°	21°	57°	38°
19:40	301°	23°	--	--	--	--	214°	16°	63°	36°
19:50	305°	26°	--	--	--	--	212°	12°	68°	34°
20:00	310°	28°	--	--	--	--	--	--	74°	32°
20:10	314°	31°	--	--	--	--	--	--	79°	29°
20:20	319°	34°	--	--	--	--	--	--	84°	27°
20:30	323°	37°	--	--	--	--	--	--	89°	24°
20:40	328°	40°	--	--	--	--	--	--	94°	22°
20:50	332°	43°	--	--	--	--	--	--	98°	19°
21:00	337°	47°	--	--	--	--	--	--	103°	16°

Table of Azimuth, Elevation and Time for HORNLAKE

28 Jun 1989
15:00 -> 21:00
Elevation : 12°

Latitude : 34° 58' 00" N
Longitude : 90° 02' 00" W
Zone : - 5:00

Satellite 12		Satellite 13		Satellite 14		Satellite --		Satellite --	
AZ	EL	AZ	EL	AZ	EL	AZ	EL	AZ	EL
--	--	--	--	--	--				
--	--	--	--	--	--				
--	--	--	--	--	--				
--	--	--	--	--	--	START 4		SV WINDOW	
--	--	--	--	--	--				
--	--	--	--	--	--				
--	--	--	--	--	--				
--	--	--	--	--	--				
--	--	--	--	--	--				
--	--	243°	13°	--	--	START 5		SV WINDOW	
--	--	247°	16°	--	--				
--	--	251°	19°	--	--				
--	--	256°	22°	--	--				
330°	13°	260°	24°	--	--				
328°	17°	265°	27°	--	--				
326°	21°	270°	29°	143°	14°				
324°	25°	275°	32°	140°	18°				
320°	28°	281°	34°	137°	21°				
317°	31°	286°	36°	134°	24°				
312°	34°	292°	38°	130°	28°				
307°	36°	298°	40°	127°	31°				
302°	38°	304°	42°	122°	34°				
296°	39°	310°	44°	118°	37°				
289°	39°	317°	46°	113°	40°				
283°	39°	323°	47°	107°	42°				
277°	38°	330°	49°	101°	44°				
271°	36°	337°	50°	94°	45°				
265°	34°	345°	52°	87°	46°				
260°	31°	353°	53°	80°	46°				
255°	28°	1°	54°	74°	45°				
251°	25°	9°	55°	67°	44°				
247°	22°	18°	56°	62°	42°				
243°	18°	27°	56°	57°	39°				
239°	15°	36°	57°	53°	36°	STOP 5		SV WINDOW	
--	--	45°	56°	49°	33°				
--	--	54°	56°	47°	29°				
--	--	63°	55°	44°	26°	STOP 4		SV WINDOW	

Figure E-7. Satellite visibility chart

GPS PROJECT No. 7-K
HORN LAKE CREEK PHOTO CONTROL Stop and Go SURVEY
HORN LAKE, MISSISSIPPI

STATION NUMBER	STATION NAME	LATITUDE	LONGITUDE	HEIGHT
3094	HOLMES 1914	34-59-27.00296	89-57-22.44228	123.897
3095	HUDGINS 1959	34-59-52.56136	90-00-07.30092	106.019
1096	LYNCHBERG 1956	34-57-45.46270	90-05-48.68871	94.000
4097	P-13-1-89	34-56-54.00000	90-02-03.00000	91.000
4098	P-13-2-89	34-56-54.00000	90-02-18.00000	84.000
2099	S 22 1974	34-57-45.00000	90-03-18.00000	80.902
5201	HL-1	34-59-30	90-05-05	74.000
5202	HL-2	34-59-18	90-05-00	75.000
5203	HL-3	34-59-30	90-04-30	72.000
5204	HL-4	34-59-13	90-03-38	75.000
5205	HL-5	34-58-40	90-03-38	75.000
5206	HL-6	34-58-45	90-02-35	79.000
5207	HL-7	34-58-15	90-02-45	79.000
5208	HL-8	34-58-20	90-01-47	80.000
5209	HL-9	34-58-02	90-02-02	78.000
5211	HL-11	34-58-10	90-01-08	81.000
5212	HL-12	34-58-05	90-02-17	80.000
5213	HL-13	34-57-40	90-02-28	80.000
5214	HL-14	34-57-38	90-02-20	80.000
5215	HL-15	34-57-12	90-02-40	84.000
5216	HL-16	34-57-10	90-02-22	83.000
5217	HL-17	34-56-58	90-02-43	84.000
5218	HL-18	34-57-45	90-01-40	80.000
5219	HL-19	34-58-15	90-01-20	85.000
5220	HL-20	34-57-45	90-01-00	82.000
5221	HL-21	34-58-47	90-00-19	96.000
5222	HL-22	34-58-20	89-59-55	91.000
5223	HL-23	34-59-02	89-59-13	100.000
5224	HL-24	34-58-39	89-59-13	90.000

WEDNESDAY JUNE 28, 1989 (179)

SESSION 1	SESSION 2	SESSION 3
HUDGINS (3095)	HUDGINS (3095)	HUDGINS (3095)
P-13-2-89(4098)	P-13-2-89(4098)	P-13-2-89(4098)
HOLMES (3094)	HOLMES (3094)	ROVER 2 BEGIN
LYNCHBURG(1096)	P-13-1-89(4097)	ROVER 1 BEGIN
START: 15:40	START: 17:05	START: 18:05
STOP: 16:50	STOP: 18:00	STOP: 20:45
SV's:03,06,08,09, 11,12,13,14	SV's:03,06,08,09 11,12,13,14	SV's:03,06,08,09, 11,12,13,14

Figure E-8. Observation schedule

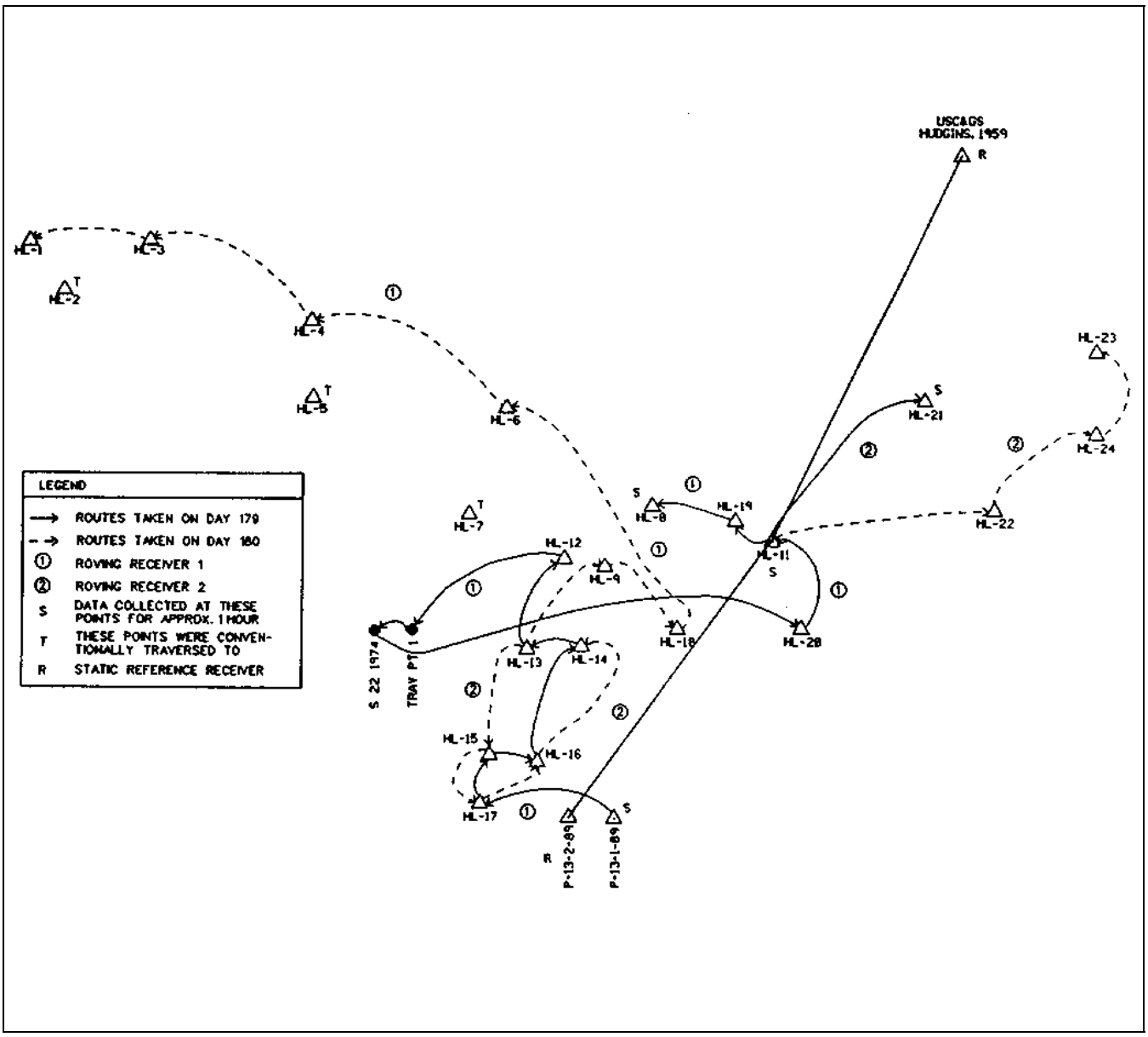


Figure E-9. Observation routes and initialization of rover 1

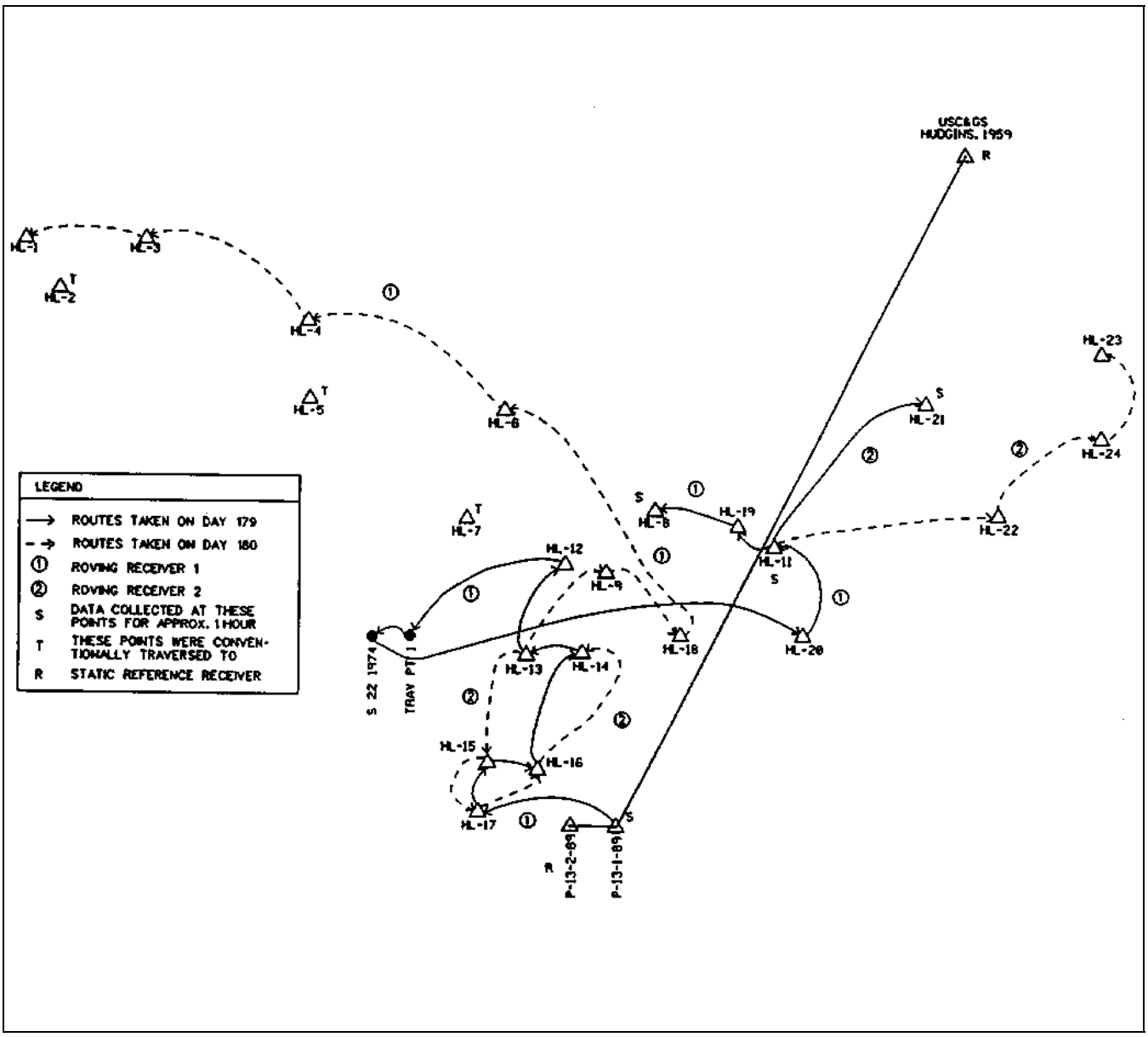


Figure E-10. Observation routes and initialization of rover 2

U.S. ARMY CORPS OF ENGINEERS
STOP & GO KINEMATIC GPS FIELD FORM

PROJECT NAME _____ LOCALITY _____
OBSERVER _____ AGENCY/FIRM _____
RECEIVER _____ S/N _____
ANTENNA _____ S/N _____
DATA RECORDING UNIT _____ S/N _____
ANTENNA MOUNTING DEVICE _____ LAST CALIBRATED: _____
DATE (MM DD YY) _____ DAY OF YEAR _____

STATIC REFERENCE RECEIVERS

	RECEIVER 1		RECEIVER 2		RECEIVER 3	
STATION NAME						
STATION NUMBER						
UTC TIME OF OBSERVATION	START	STOP	START	STOP	START	STOP

STOP & GO ROVING RECEIVER

STATION NUMBER	STATION NAME	ANTENNA HEIGHT	DATA SET #	COMMENTS

PAGE 1 SHEET ___ OF ___

Figure E-11. Stop-and-go kinematic field form (Continued)

U.S. ARMY CORPS OF ENGINEERS
STOP & GO KINEMATIC GPS FIELD FORM

****

STOP & GO ROVING RECEIVER CON'T

STATION NUMBER	STATION NAME	ANTENNA HEIGHT	DATA SET #	COMMENTS

****

ADDITIONAL COMMENTS

PAGE 2

Figure E-11. (Concluded)

U.S. ARMY CORPS OF ENGINEERS
STOP & GO KINEMATIC GPS FIELD FORM

PROJECT NAME Horn Lake Creek GPS-7K LOCALITY Horn Lake, Ms
OBSERVER C. Waite & C.D. Wilbanks AGENCY/FIRM CoE, Memphis District
RECEIVER Trimble 4000 SL S/N 2820A00242
ANTENNA Trimble Micro SL S/N 2923A00242
DATA RECORDING UNIT Receiver S/N 2820A00242
ANTENNA MOUNTING DEVICE Range Pole & Bipod LAST CALIBRATED: 06/27/89
DATE (MM DD YY) 06/28/89 DAY OF YEAR 179

STATIC REFERENCE RECEIVERS

	RECEIVER 1	RECEIVER 2	RECEIVER 3
STATION NAME	Hudgins	P-13-2-89	
STATION NUMBER	3095	4098	
UTC TIME OF OBSERVATION	START 20:39 STOP 01:45	START 22:03 STOP 01:46	START STOP

STOP & GO ROVING RECEIVER

STATION NUMBER	STATION NAME	ANTENNA HEIGHT	DATA SET #	COMMENTS
4097	P-13-1-89	1.963	1	Static Initialization 22:04 - 22:00 UTC Lost Lock Traveling To Next Pt.
4097	P-13-1-89	"	2	Returned To Reinitialize
5217	HL-17	"	3	Antenna Disturbed
5217	HL-17	"	4	Reoccupied
5215	HL-15	"	5	
7211	Return Pt A	"	6	PK Nail at E of NW End of Meadowbrook Rd Bridge over Cow Pen Creek
5216	HL-16	"	7	
5214	HL-14	"	8	
5213	HL-13	"	9	
5212	HL-12	"	10	
7212	Trav Pt 1	"	11	PK Nail at N/Edge Goodman Rd 0.45 m E of Horn Lake Rd.
2099	S 22 1974	"	12	Bench Mark on Culvert Headwall
5220	HL-20	"	13	

PAGE 1 SHEET 1 OF 1

Figure E-12. Example stop-and-go kinematic field form (Continued)

U.S. ARMY CORPS OF ENGINEERS
STOP & GO KINEMATIC GPS FIELD FORM

****

STOP & GO ROVING RECEIVER CON'T

STATION NUMBER	STATION NAME	ANTENNA HEIGHT	DATA SET #	COMMENTS
5211	HL-11	1.963	14	
5219	HL-19	"	15	
5208	HL-8	"	16	LOST LOCK TRAVELING TO THIS POINT OCCUPIED STATICALLY FROM 00:42 TO 01:45 UTC

****

ADDITIONAL COMMENTS

7212-TRAV PT 1 AND 2099-522 1974 WILL BE USED AS BEGINNING AND ENDING HORIZONTAL CONTROL FOR TRAVERSE TO HL-7. 522 1974 WILL BE USED AS VERTICAL CONTROL FOR DIFFERENTIAL LEVELS TO HL-7.

PAGE 2

Figure E-12. (Concluded)

TRIMVEC GPS RELATIVE POSITIONING SOLUTION SUMMARY: VERSION 89.062

SOLUTION OUTPUT FILE: D:\179\OUT\95971792.fix

STATION 1: Station ID: 3095 Session #: 179-1 Jun 28, 1989 19:22
Data-logging start time = 20:39 Data-logging stop time = 01:45

STATION 2: Station ID: 4097 Session #: 179-2 Jun 28, 1989 22:04
Data-logging start time = 22:04 Data-logging stop time = 23:00

STATION COORDINATES:

Sta	Ant (m)	Latitude	Longitude	Hgt (m)
1	1.409	34:59'52.56136" N	90:00'07.30092" W	106.019
2 [TRP]	1.963	34:56'53.54740" N	90:02'03.76506" W	91.051
2 [FLT]	1.963	34:56'53.54594" N	90:02'03.76283" W	91.073
2 [FIX]	1.963	34:56'53.54605" N	90:02'03.76258" W	91.089

Origin of station 1 coordinates : User input

SOLUTION SUMMARY:

Solution	dx (m)	dy (m)	dz (m)	dh (m)	RDOP
TRIPLE	-2955.290	-3148.922	-4529.085	-14.969	4.329
FLOAT	-2955.234	-3148.966	-4529.109	-14.946	0.354
*FIXED	-2955.228	-3148.977	-4529.097	-14.930	0.048
FLT-FIX	-0.006	0.011	-0.012	-0.015	

Solution	Slope (m)	sig	Epochs/Rejected	Epoch interval	Epoch increment
TRIPLE	6257.9599	[0.064]	102/ 6	150 (secs)	5 (epochs)
FLOAT	6257.9727	[0.032]	546/ 27	30 (secs)	1 (epochs)
FIXED	6257.9668	[0.014]	545/ 28	30 (secs)	1 (epochs)

Fixed solution quality factor: 10.1
Fixed solution rms: 0.039 (cycles)
Maximum float - fixed delta: 1.2 (cm)

Integers found, RMS is OK, FIXED solution recommended.

Figure E-13. Static solution summary 3095 -> 4097

TRIMVEC GPS RELATIVE POSITIONING SOLUTION SUMMARY: VERSION 89.062

SOLUTION OUTPUT FILE: D:\179\OUT\98971792.fix

STATION 1: Station ID: 4098 Session #: 179-1 Jun 28, 1989 20:38
Data-logging start time = 20:42 Data-logging stop time = 01:45

STATION 2: Station ID: 4097 Session #: 179-2 Jun 28, 1989 22:04
Data-logging start time = 22:04 Data-logging stop time = 23:00

STATION COORDINATES:

Sta	Ant (m)	Latitude	Longitude	Hgt (m)
1	1.590	34:56'53.35126" N	90:02'18.20974" W	83.300
2 [TRP]	1.963	34:56'53.54487" N	90:02'03.76471" W	91.136
2 [FLT]	1.963	34:56'53.54503" N	90:02'03.76453" W	91.114
2 [FIX]	1.963	34:56'53.54458" N	90:02'03.76338" W	91.120

Origin of station 1 coordinates : User input

SOLUTION SUMMARY:

Solution	dx (m)	dy (m)	dz (m)	dh (m)	RDOP
TRIPLE	366.528	-3.238	9.379	7.836	4.303
FLOAT	366.533	-3.217	9.371	7.814	0.354
*FIXED	366.562	-3.230	9.363	7.820	0.047
FLT-FIX	-0.029	0.013	0.008	-0.006	

Solution	Slope (m)	sig	Epochs/Rejected	Epoch interval	Epoch increment
TRIPLE	366.6626	[0.106]	107/ 1	150 (secs)	5 (epochs)
FLOAT	366.6667	[0.006]	570/ 3	30 (secs)	1 (epochs)
FIXED	366.6960	[0.002]	569/ 4	30 (secs)	1 (epochs)

Fixed solution quality factor: 29.7
Fixed solution rms: 0.024 (cycles)
Maximum float - fixed delta: 2.9 (cm)

Integers found, RMS is large. (see Trimvec Manual).

Figure E-14. Static solution summary 4098 -> 4097

quality factors were fairly high, meaning that the integer-cycle ambiguities were resolved in both solutions with a high degree of reliability. Even though the RMS was slightly large in comparison to the length of the baseline from 4098 to 4097, the fixed solution quality factor was high and thus the results of the fixed solution are recommended. Had sufficient data not been collected to resolve the integer cycle ambiguities, additional static data collection would be required. An attempt to process stop-and-go data using values from static solutions in which the integers were not found may give erroneous results for the baselines processed. The dX, dY, and dZ values listed for the fixed solution in Figures E-13 and E-14 were used to post-process the stop-and-go data.

b. After all static data were processed, summaries of the stop-and-go sessions were printed. These summaries document the events of the session and the time of their occurrence in GPS seconds of the week. Figure E-15 shows the summary of events that took place during the stop-and-go session on day 179 between the reference receiver at station 3095 and roving receiver initializing on station 4097. The stop-and-go session summary conveys the following details of the survey.

(1) The data file names for the reference and remote (roving) receivers.

(2) The kinematic (stop-and-go) data set number. This number was automatically incremented by one each time a point was occupied.

(3) The station ID of the point being occupied.

(4) The time in seconds that the data set began.

(5) The height of the roving receiver's antenna above the point being occupied.

(6) The time in seconds that the data set ended.

(7) The amount of time in minutes and seconds that data were recorded at the point being occupied.

(8) The last epoch of data recorded before missing satellite PRN 14. The satellite was missing because a cycle slip occurred or a loss of data occurred during download from the receiver to the computer.

(9) The last epoch of data recorded before a cycle slip occurred on satellite PRN 6.

(10) The number of satellites the receiver was locked onto after missing PRN 14 and a cycle slip on PRN 6.

(11) At this point, lock was not maintained on at least four satellites. The survey was reinitialized by returning to the last point occupied; also a new route was chosen to the next point.

(12) The travel time in minutes and seconds that it took to move to the next point, or in this case, to go back to the last occupied point.

(13) The typical observation time at each stop-and-go point.

(14) At this point, lock could not be maintained on at least four satellites. The low elevation of the remaining visible satellites indicated that reinitialization would have been futile.

(15) Since there was slightly over an hour of the four-satellite window remaining on day 179, the survey continued to station 5208 where static observations were recorded for 63 minutes.

(16) Stations within a linked data set were stations consecutively occupied while lock was maintained on at least four satellites. At the point when lock was no longer maintained on at least four satellites, a new linked data set was started.

(17) The station occupation data indicate how many times each point was occupied and to which data set each occupation corresponds.

Figure E-16 shows the summary of events that took place during the stop-and-go session on day 179 between the reference receiver at station 4098 and roving receiver initializing on station 4097. Figures E-15 and E-16 are similar, but they are not exactly the same. A comparison of the two summaries reveals that other than the reference receivers being at different locations, the only other difference is in some of the times when cycle slips or missing satellite data occurred. Since the data from the roving receiver were common to both summaries, the differences in times of missing satellite data were due to obstructions at the reference receiver's location. The roving receiver operator can observe only cycle slips occurring at his receiver. Each receiver in the stop-and-go mode is able to warn the operator with a series of beeps when it no

```
Trimble Automated Kinematic Processor,  Version 89.120
Kinematic Summary of Session: 179

Reference Receiver Data File: 30951791 (a)
Remote Receiver Data File:    40971792
Reference PRN #:              11
                          (b)        (c)                   (d)               (e)
KINEMATIC DATA SET:   1   ID: 4097   Time:    338835    Ant height: 2.0000
   New Scenario Add  SV    PRN: 12   Time:    339210
    SV Count:           6            Time:    339210
    Last Before Missing    PRN: 12   Time:    339360
    SV Count:           5            Time:    339360
           Recovered SV    PRN: 12   Time:    339405   *STATIC INITIALIZATION
    SV Count:           6            Time:    339405    (OR KNOWN BASELINE
   New Scenario Add  SV    PRN: 14   Time:    340260     AFTER PROCESSING)
    SV Count:           7            Time:    340260
END OF KINEMATIC DATA     ID: 4097   Time:    341985 (f) Ant height: 2.0000
OBSERVATION TIME: 55:15 (g)

    Last Before Missing    PRN: 14   Time:    342225 (h)
       Last Before Slip    PRN:  6   Time:    342225   (i)
    SV Count:           5 (j)        Time:    342225
       Last Before Slip    PRN:  8   Time:    342240
       Last Before Slip    PRN:  9   Time:    342240
       Last Before Slip    PRN: 11   Time:    342240
       Last Before Slip    PRN: 12   Time:    342240
       Last Before Slip    PRN: 13   Time:    342240
    SV Count:           0            Time:    342240
       After Cycle Slip    PRN:  6   Time:    342270   *LOST LOCK ON SATELLITES
       After Cycle Slip    PRN:  8   Time:    342270    WHILE MOVING, RETURNED
       After Cycle Slip    PRN:  9   Time:    342270    TO LAST OCCUPIED POINT.
       After Cycle Slip    PRN: 11   Time:    342270    (SEE DATA SET 2 BELOW)
       After Cycle Slip    PRN: 12   Time:    342270
           Recovered SV    PRN: 14   Time:    342270
    SV Count:           6            Time:    342270
       After Cycle Slip    PRN: 13   Time:    342315
    SV Count:           7            Time:    342315
       Last Before Slip    PRN:  6   Time:    342330
       Last Before Slip    PRN: 14   Time:    342330
    SV Count:           5            Time:    342330
       After Cycle Slip    PRN: 14   Time:    342375
    SV Count:           6            Time:    342375
       After Cycle Slip    PRN:  6   Time:    342420
    Last Before Missing    PRN:  8   Time:    342420
    Last Before Missing    PRN: 14   Time:    342420
    SV Count:           5            Time:    342420
           Recovered SV    PRN:  8   Time:    342465
    SV Count:           6            Time:    342465
           Recovered SV    PRN: 14   Time:    342480
    SV Count:           7            Time:    342480
MOVE TIME:  9:44 (l)

KINEMATIC DATA SET:  2    ID: 4097   Time:    342585    Ant height: 2.0000
END OF KINEMATIC DATA     ID: 4097   Time:    342645    Ant height: 2.0000
OBSERVATION TIME:  1:15   *RETURNED TO REINITIALIZE WITH KNOWN BASELINE
                  (m)
```

Figure E-15. Kinematic session summary 3095 -> 4097 (Sheet 1 of 6)

```
      Last Before Slip   PRN:  6   Time:   342810
   SV Count:          6            Time:   342810
      After Cycle Slip   PRN:  6   Time:   342840
   SV Count:          7            Time:   342840
MOVE TIME:  6:59

KINEMATIC DATA SET:  3   ID: 5217   Time:   343080    Ant height: 2.0000
END OF KINEMATIC DATA    ID: 5217   Time:   343260    Ant height: 2.0000
OBSERVATION TIME:  3:15  *SETUP WAS DISTURBED DURING OCCUPATION,
                          SEE DATA SET 4 FOR REOCCUPATION

MOVE TIME:  0:59

KINEMATIC DATA SET:  4   ID: 5217   Time:   343335    Ant height: 2.0000
END OF KINEMATIC DATA    ID: 5217   Time:   343395    Ant height: 2.0000
OBSERVATION TIME:  1:15

    Last Before Missing   PRN:  8   Time:   343545
    SV Count:          6            Time:   343545
MOVE TIME:  4: 0

KINEMATIC DATA SET:  5   ID: 5215   Time:   343650    Ant height: 2.0000
KINEMATIC DATA SET:  5   ID: 5215   Time:   343680    Ant height: 2.0000
         Recovered SV    PRN:  8   Time:   343710
    SV Count:          7            Time:   343710
END OF KINEMATIC DATA    ID: 5215   Time:   343710    Ant height: 2.0000
OBSERVATION TIME:  1:15

    Last Before Missing   PRN:  8   Time:   343845
    SV Count:          6            Time:   343845
         Recovered SV    PRN:  8   Time:   343935
    Last Before Missing   PRN:  6   Time:   343935
         Recovered SV    PRN:  6   Time:   343965
    SV Count:          7            Time:   343965
    Last Before Missing   PRN:  8   Time:   343980
    SV Count:          6            Time:   343980
    Last Before Missing   PRN:  6   Time:   344010
    SV Count:          5            Time:   344010
         Recovered SV    PRN:  6   Time:   344130
    SV Count:          6            Time:   344130
MOVE TIME:  7:14

KINEMATIC DATA SET:  6   ID: 7211   Time:   344160    Ant height: 2.0000
KINEMATIC DATA SET:  6   ID: 7211   Time:   344220    Ant height: 2.0000
END OF KINEMATIC DATA    ID: 7211   Time:   344220    Ant height: 2.0000
OBSERVATION TIME:  1:15  *THIS POINT WAS ESTABLISHED TO RETURN TO IN CASE
                          LOCK WAS LOST ON THE WAY TO POINT 5216

    Last Before Missing   PRN:  6   Time:   344250
    SV Count:          5            Time:   344250
   New Scenario Lost SV   PRN:  6   Time:   344415
MOVE TIME:  4:14

KINEMATIC DATA SET:  7   ID: 5216   Time:   344490    Ant height: 2.0000
END OF KINEMATIC DATA    ID: 5216   Time:   344550    Ant height: 2.0000
OBSERVATION TIME:  1:15
```

Figure E-15. (Sheet 2 of 6)

```
      Last Before Slip   PRN: 12   Time:   344700
   SV Count:          4             Time:   344700
        Recovered SV     PRN:  8   Time:   344730
   SV Count:          5             Time:   344730
      After Cycle Slip   PRN: 12   Time:   344745
   SV Count:          6             Time:   344745
   Last Before Missing   PRN:  8   Time:   344760
   SV Count:          5             Time:   344760
MOVE TIME:  6:29

KINEMATIC DATA SET:  8   ID: 5214   Time:   344955   Ant height: 2.0000
END OF KINEMATIC DATA    ID: 5214   Time:   345015   Ant height: 2.0000
OBSERVATION TIME:  1:15

          Recovered SV    PRN:  8   Time:   345165
      Last Before Slip    PRN:  8   Time:   345165
      After Cycle Slip    PRN:  8   Time:   345210
   SV Count:          6             Time:   345210
      Last Before Slip    PRN:  8   Time:   345270
   SV Count:          5             Time:   345270
  New Scenario Lost SV    PRN:  8   Time:   345330
MOVE TIME:  5:30

KINEMATIC DATA SET:  9   ID: 5213   Time:   345360   Ant height: 2.0000
END OF KINEMATIC DATA    ID: 5213   Time:   345420   Ant height: 2.0000
OBSERVATION TIME:  1:14

MOVE TIME:  6: 0

KINEMATIC DATA SET: 10   ID: 5212   Time:   345795   Ant height: 2.0000
END OF KINEMATIC DATA    ID: 5212   Time:   345855   Ant height: 2.0000
OBSERVATION TIME:  1:15

   New Scenario Add  SV    PRN:  3   Time:   345900
    SV Count:          6             Time:   345900
    Last Before Missing    PRN:  3   Time:   345960
    SV Count:          5             Time:   345960
          Recovered SV     PRN:  3   Time:   346050
    SV Count:          6             Time:   346050
MOVE TIME:  6:44

KINEMATIC DATA SET: 11   ID: 7212   Time:   346275   Ant height: 2.0000
END OF KINEMATIC DATA    ID: 7212   Time:   346335   Ant height: 2.0000
OBSERVATION TIME:  1:15

      Last Before Slip    PRN:  3   Time:   346485
   SV Count:          5             Time:   346485
      After Cycle Slip    PRN:  3   Time:   346515
   SV Count:          6             Time:   346515
MOVE TIME:  3:14

KINEMATIC DATA SET: 12   ID: 2099   Time:   346545   Ant height: 2.0000
END OF KINEMATIC DATA    ID: 2099   Time:   346620   Ant height: 2.0000
OBSERVATION TIME:  1:30
```

Figure E-15. (Sheet 3 of 6)

```
      Last Before Slip   PRN:  9   Time:   346815
   SV Count:           5            Time:   346815
      After Cycle Slip   PRN:  9   Time:   346845
   SV Count:           6            Time:   346845
   Last Before Missing   PRN:  9   Time:   346890
   SV Count:           5            Time:   346890
         Recovered SV    PRN:  9   Time:   346935
      Last Before Slip   PRN:  9   Time:   346935
      After Cycle Slip   PRN:  9   Time:   347010
   SV Count:           6            Time:   347010
MOVE TIME:  8:15

KINEMATIC DATA SET: 13   ID: 5220   Time:   347130    Ant height: 2.0000
END OF KINEMATIC DATA    ID: 5220   Time:   347190    Ant height: 2.0000
OBSERVATION TIME:  1:15

MOVE TIME:  4:29

KINEMATIC DATA SET: 14   ID: 5211   Time:   347475    Ant height: 2.0000
END OF KINEMATIC DATA    ID: 5211   Time:   347535    Ant height: 2.0000
OBSERVATION TIME:  1:15

      Last Before Slip   PRN:  9   Time:   347730
   SV Count:           5            Time:   347730
      After Cycle Slip   PRN:  9   Time:   347760
   SV Count:           6            Time:   347760
MOVE TIME:  3:45

KINEMATIC DATA SET: 15   ID: 5219   Time:   347775    Ant height: 2.0000
END OF KINEMATIC DATA    ID: 5219   Time:   347835    Ant height: 2.0000
OBSERVATION TIME:  1:15

   Last Before Missing   PRN:  9   Time:   347895
      Last Before Slip   PRN:  3   Time:   347895
   SV Count:           4            Time:   347895
      After Cycle Slip   PRN:  3   Time:   347940
      Last Before Slip   PRN:  3   Time:   347940
      Last Before Slip   PRN: 11   Time:   347940
   SV Count:           3            Time:   347940(η)*AT THIS POINT LOCK WAS
      After Cycle Slip   PRN: 11   Time:   347970    NOT MAINTAINED ON AT
   SV Count:           4            Time:   347970    LEAST 4 SATELLIES
      Last Before Slip   PRN: 13   Time:   347986
   SV Count:           3            Time:   347986
   Last Before Missing   PRN: 12   Time:   348000
   SV Count:           2            Time:   348000
      After Cycle Slip   PRN:  3   Time:   348015
      After Cycle Slip   PRN: 13   Time:   348015
      Last Before Slip   PRN:  3   Time:   348015
      Last Before Slip   PRN: 11   Time:   348015
      Last Before Slip   PRN: 13   Time:   348015
      Last Before Slip   PRN: 14   Time:   348015
   SV Count:           0            Time:   348015
```

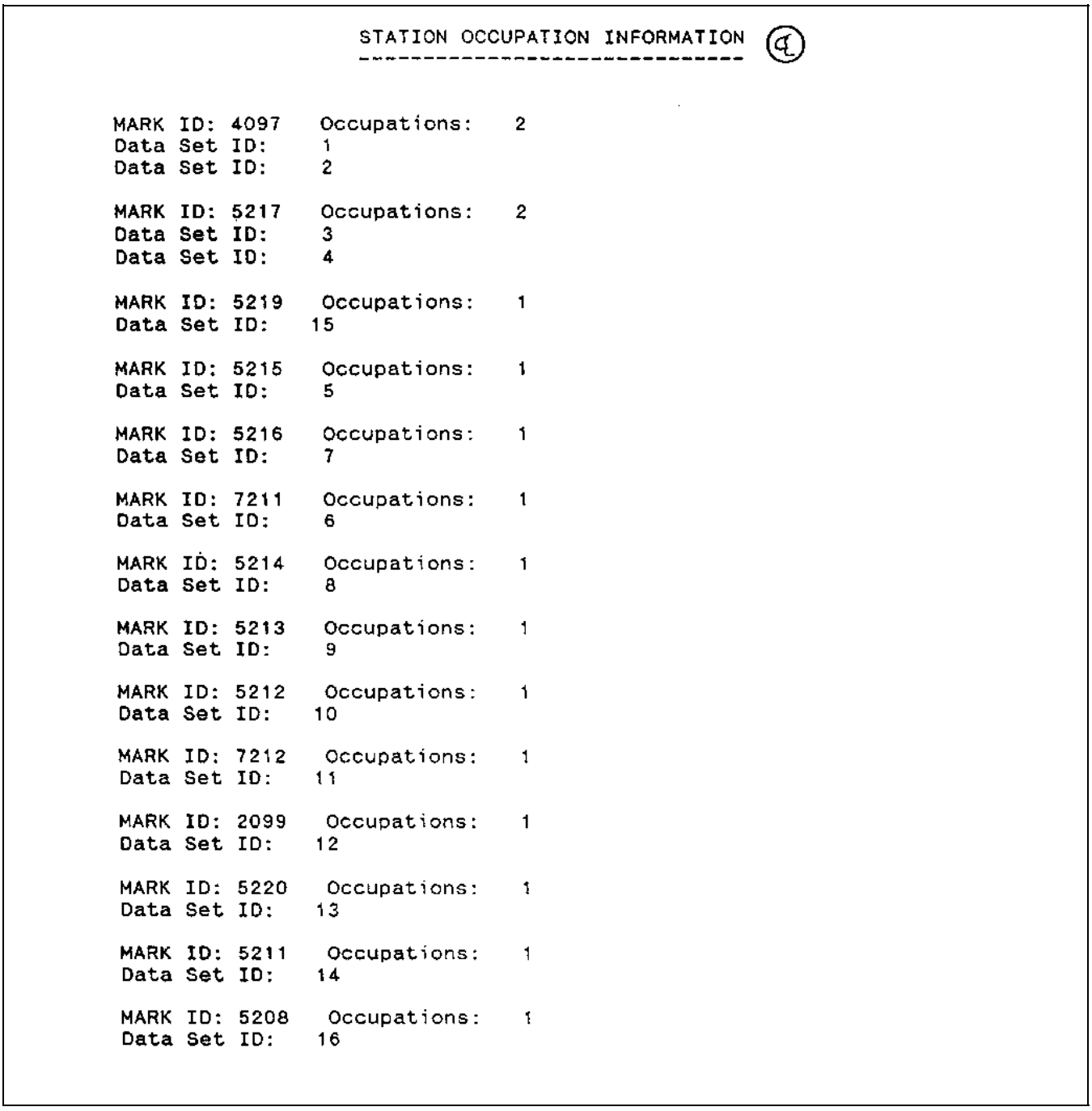
Figure E-15. (Sheet 4 of 6)

```
        After Cycle Slip   PRN: 11   Time:   348045
            Recovered SV   PRN: 12   Time:   348045
        After Cycle Slip   PRN: 14   Time:   348045
        Last Before Slip   PRN: 12   Time:   348045
    SV Count:           2             Time:   348045
        After Cycle Slip   PRN:  3   Time:   348075
        After Cycle Slip   PRN: 12   Time:   348075
        After Cycle Slip   PRN: 13   Time:   348075
    SV Count:           5             Time:   348075
            Recovered SV   PRN:  9   Time:   348090
    SV Count:           6             Time:   348090
MOVE TIME:  5: 0

 KINEMATIC DATA SET: 16   ID: 5208 (o) Time:   348150   Ant height: 2.0000
 KINEMATIC DATA SET: 16   ID: 5208    Time:   348195   Ant height: 2.0000
     Last Before Missing   PRN:  9    Time:   348420
     SV Count:           5             Time:   348420   *DUE TO THE ABOVE LOSS OF
    New Scenario Lost SV   PRN:  9    Time:   348435    LOCK, THIS POINT WAS
     Last Before Missing   PRN: 12    Time:   351180    OCCUPIED FOR 63 MINUTES
     SV Count:           4             Time:   351180    AND THE DATA PROCESSED
    New Scenario Lost SV   PRN: 12    Time:   351195    AS A STATIC BASELINE.
 END OF KINEMATIC DATA    ID: 5208    TIME:   351930
 OBSERVATION TIME: 63:00

(p) Linked Data Set # 1:   - 4097
(p) Linked Data Set # 2:   - 4097 - 5217 - 5217 - 5215 - 7211 - 5216 - 5214
                           - 5213 - 5212 - 7212 - 2099 - 5220 - 5211 - 5219
    Linked Data Set # 3:   - 5208
```

Figure E-15. (Sheet 5 of 6)



STATION OCCUPATION INFORMATION (4)

MARK ID: 4097 Occupations: 2
Data Set ID: 1
Data Set ID: 2

MARK ID: 5217 Occupations: 2
Data Set ID: 3
Data Set ID: 4

MARK ID: 5219 Occupations: 1
Data Set ID: 15

MARK ID: 5215 Occupations: 1
Data Set ID: 5

MARK ID: 5216 Occupations: 1
Data Set ID: 7

MARK ID: 7211 Occupations: 1
Data Set ID: 6

MARK ID: 5214 Occupations: 1
Data Set ID: 8

MARK ID: 5213 Occupations: 1
Data Set ID: 9

MARK ID: 5212 Occupations: 1
Data Set ID: 10

MARK ID: 7212 Occupations: 1
Data Set ID: 11

MARK ID: 2099 Occupations: 1
Data Set ID: 12

MARK ID: 5220 Occupations: 1
Data Set ID: 13

MARK ID: 5211 Occupations: 1
Data Set ID: 14

MARK ID: 5208 Occupations: 1
Data Set ID: 16

Figure E-15. (Sheet 6 of 6)

```
Trimble Automated Kinematic Processor,  Version 89.120
Kinematic Summary of Session: 179

Reference Receiver Data File: 40981791
Remote Receiver Data File:    40971792
Reference PRN #:              11

KINEMATIC DATA SET:  1   ID: 4097   Time:   338835   Ant height: 2.0000
   New Scenario Add  SV   PRN: 12   Time:   339210
    SV Count:           6            Time:   339210
    Last Before Missing   PRN: 12   Time:   339360
    SV Count:           5            Time:   339360   *STATIC INITIALIZATION
          Recovered SV    PRN: 12   Time:   339405    (OR KNOWN BASELINE
    SV Count:           6            Time:   339405     AFTER PROCESSING)
   New Scenario Add  SV   PRN: 14   Time:   340320
    Last Before Missing   PRN: 14   Time:   340320
          Recovered SV    PRN: 14   Time:   340425
    SV Count:           7            Time:   340425
END OF KINEMATIC DATA    ID: 4097   Time:   341985   Ant height: 2.0000
OBSERVATION TIME: 55:15

    Last Before Missing   PRN: 14   Time:   342225
       Last Before Slip   PRN:  6   Time:   342225
    SV Count:           5            Time:   342225
       Last Before Slip   PRN:  8   Time:   342240
       Last Before Slip   PRN:  9   Time:   342240
       Last Before Slip   PRN: 11   Time:   342240
       Last Before Slip   PRN: 12   Time:   342240
       Last Before Slip   PRN: 13   Time:   342240
    SV Count:           0            Time:   342240   *LOST LOCK ON SATELLITES
       After Cycle Slip   PRN:  6   Time:   342270    WHILE MOVING, RETURNED
       After Cycle Slip   PRN:  8   Time:   342270    TO LAST OCCUPIED POINT.
       After Cycle Slip   PRN:  9   Time:   342270    (SEE DATA SET 2 BELOW)
       After Cycle Slip   PRN: 11   Time:   342270
       After Cycle Slip   PRN: 12   Time:   342270
           Recovered SV   PRN: 14   Time:   342270
    SV Count:           6            Time:   342270
       After Cycle Slip   PRN: 13   Time:   342315
    SV Count:           7            Time:   342315
       Last Before Slip   PRN:  6   Time:   342330
       Last Before Slip   PRN: 14   Time:   342330
    SV Count:           5            Time:   342330
       After Cycle Slip   PRN: 14   Time:   342375
    SV Count:           6            Time:   342375
       After Cycle Slip   PRN:  6   Time:   342420
    Last Before Missing   PRN:  8   Time:   342420
    Last Before Missing   PRN: 14   Time:   342420
    SV Count:           5            Time:   342420
          Recovered SV    PRN:  8   Time:   342465
    SV Count:           6            Time:   342465
          Recovered SV    PRN: 14   Time:   342480
    SV Count:           7            Time:   342480
 MOVE TIME:  9:44
```

Figure E-16. Kinematic session summary 4098 -> 4097 (Sheet 1 of 6)

```
KINEMATIC DATA SET:  2   ID: 4097   Time:   342585    Ant height: 2.0000
END OF KINEMATIC DATA    ID: 4097   Time:   342645    Ant height: 2.0000
OBSERVATION TIME:  1:15  *RETURNED TO REINITIALIZE WITH KOWN BASELINE

      Last Before Slip   PRN:  6   Time:   342810
   SV Count:          6             Time:   342810
      After Cycle Slip   PRN:  6   Time:   342840
   SV Count:          7             Time:   342840
MOVE TIME:  6:59

KINEMATIC DATA SET:  3   ID: 5217   Time:   343080    Ant height: 2.0000
END OF KINEMATIC DATA    ID: 5217   Time:   343260    Ant height: 2.0000
OBSERVATION TIME:  3:15  *SETUP DISTURBED DURING OCCUPATION,
                          SEE DATA SET 4 FOR REOCCUPATION.
MOVE TIME:  0:59

KINEMATIC DATA SET:  4   ID: 5217   Time:   343335    Ant height: 2.0000
END OF KINEMATIC DATA    ID: 5217   Time:   343395    Ant height: 2.0000
OBSERVATION TIME:  1:15

MOVE TIME:  4: 0

KINEMATIC DATA SET:  5   ID: 5215   Time:   343650    Ant height: 2.0000
KINEMATIC DATA SET:  5   ID: 5215   Time:   343680    Ant height: 2.0000
END OF KINEMATIC DATA    ID: 5215   Time:   343710    Ant height: 2.0000
OBSERVATION TIME:  1:15

    Last Before Missing   PRN:  8   Time:   343845
    SV Count:          6             Time:   343845
          Recovered SV    PRN:  8   Time:   343935
    Last Before Missing   PRN:  6   Time:   343935
          Recovered SV    PRN:  6   Time:   343965
    SV Count:          7             Time:   343965
    Last Before Missing   PRN:  6   Time:   344010
    SV Count:          6             Time:   344010
    Last Before Missing   PRN:  8   Time:   344055
    SV Count:          5             Time:   344055
          Recovered SV    PRN:  6   Time:   344130
    Last Before Missing   PRN:  6   Time:   344130
   New Scenario Lost SV   PRN:  6   Time:   344145
          Recovered SV    PRN:  8   Time:   344145
    SV Count:          6             Time:   344145
MOVE TIME:  7:14

KINEMATIC DATA SET:  6   ID: 7211   Time:   344160    Ant height: 2.0000
KINEMATIC DATA SET:  6   ID: 7211   Time:   344220    Ant height: 2.0000
END OF KINEMATIC DATA    ID: 7211   Time:   344220    Ant height: 2.0000
OBSERVATION TIME:  1:15   *THIS POINT WAS ESTABLISHED TO RETURN TO IN CASE
                           LOCK WAS LOST ON THE WAY TO POINT 5216.
      Last Before Slip   PRN:  8   Time:   344295
    SV Count:          5             Time:   344295
      After Cycle Slip   PRN:  8   Time:   344340
    SV Count:          6             Time:   344340
    Last Before Missing   PRN:  8   Time:   344370
    SV Count:          5             Time:   344370
          Recovered SV    PRN:  8   Time:   344430
    SV Count:          6             Time:   344430
MOVE TIME:  4:14
```

Figure E-16. (Sheet 2 of 6)

```
KINEMATIC DATA SET:  7   ID: 5216   Time:   344490    Ant height: 2.0000
END OF KINEMATIC DATA    ID: 5216   Time:   344550    Ant height: 2.0000
OBSERVATION TIME:  1:15

    Last Before Missing   PRN:  8   Time:   344655
    SV Count:          5            Time:   344655
       Last Before Slip   PRN: 12   Time:   344700
    SV Count:          4            Time:   344700
          Recovered SV    PRN:  8   Time:   344730
    SV Count:          5            Time:   344730
       After Cycle Slip   PRN: 12   Time:   344745
    SV Count:          6            Time:   344745
    Last Before Missing   PRN:  8   Time:   344775
    SV Count:          5            Time:   344775
          Recovered SV    PRN:  8   Time:   344865
    SV Count:          6            Time:   344865
MOVE TIME:  6:29

KINEMATIC DATA SET:  8   ID: 5214   Time:   344955    Ant height: 2.0000
END OF KINEMATIC DATA    ID: 5214   Time:   345015    Ant height: 2.0000
OBSERVATION TIME:  1:15

    Last Before Missing   PRN:  8   Time:   345090
    SV Count:          5            Time:   345090
          Recovered SV    PRN:  8   Time:   345165
       Last Before Slip   PRN:  8   Time:   345165
       After Cycle Slip   PRN:  8   Time:   345210
    SV Count:          6            Time:   345210
       Last Before Slip   PRN:  8   Time:   345270
    SV Count:          5            Time:   345270
       After Cycle Slip   PRN:  8   Time:   345345
    SV Count:          6            Time:   345345
MOVE TIME:  5:30

KINEMATIC DATA SET:  9   ID: 5213   Time:   345360    Ant height: 2.0000
END OF KINEMATIC DATA    ID: 5213   Time:   345420    Ant height: 2.0000
OBSERVATION TIME:  1:14

    Last Before Missing   PRN:  8   Time:   345480
    SV Count:          5            Time:   345480
   New Scenario Lost SV   PRN:  8   Time:   345495
MOVE TIME:  6: 0

KINEMATIC DATA SET: 10   ID: 5212   Time:   345795    Ant height: 2.0000
END OF KINEMATIC DATA    ID: 5212   Time:   345855    Ant height: 2.0000
OBSERVATION TIME:  1:15

   New Scenario Add  SV   PRN:  3   Time:   345900
    SV Count:          6            Time:   345900
MOVE TIME:  6:44

KINEMATIC DATA SET: 11   ID: 7212   Time:   346275    Ant height: 2.0000
END OF KINEMATIC DATA    ID: 7212   Time:   346335    Ant height: 2.0000
OBSERVATION TIME:  1:15

       Last Before Slip   PRN:  3   Time:   346485
    SV Count:          5            Time:   346485
       After Cycle Slip   PRN:  3   Time:   346515
    SV Count:          6            Time:   346515
MOVE TIME:  3:14
```

Figure E-16. (Sheet 3 of 6)

```
KINEMATIC DATA SET: 12   ID: 2099   Time:   346545    Ant height: 2.0000
END OF KINEMATIC DATA    ID: 2099   Time:   346620    Ant height: 2.0000
OBSERVATION TIME:  1:30

      Last Before Slip   PRN:  9   Time:   346815
   SV Count:          5             Time:   346815
      After Cycle Slip   PRN:  9   Time:   346845
   SV Count:          6             Time:   346845
   Last Before Missing   PRN:  9   Time:   346890
   SV Count:          5             Time:   346890
         Recovered SV   PRN:  9   Time:   346935
      Last Before Slip   PRN:  9   Time:   346935
      After Cycle Slip   PRN:  9   Time:   347010
   SV Count:          6             Time:   347010
MOVE TIME:  8:15

KINEMATIC DATA SET: 13   ID: 5220   Time:   347130    Ant height: 2.0000
END OF KINEMATIC DATA    ID: 5220   Time:   347190    Ant height: 2.0000
OBSERVATION TIME:  1:15

MOVE TIME:  4:29

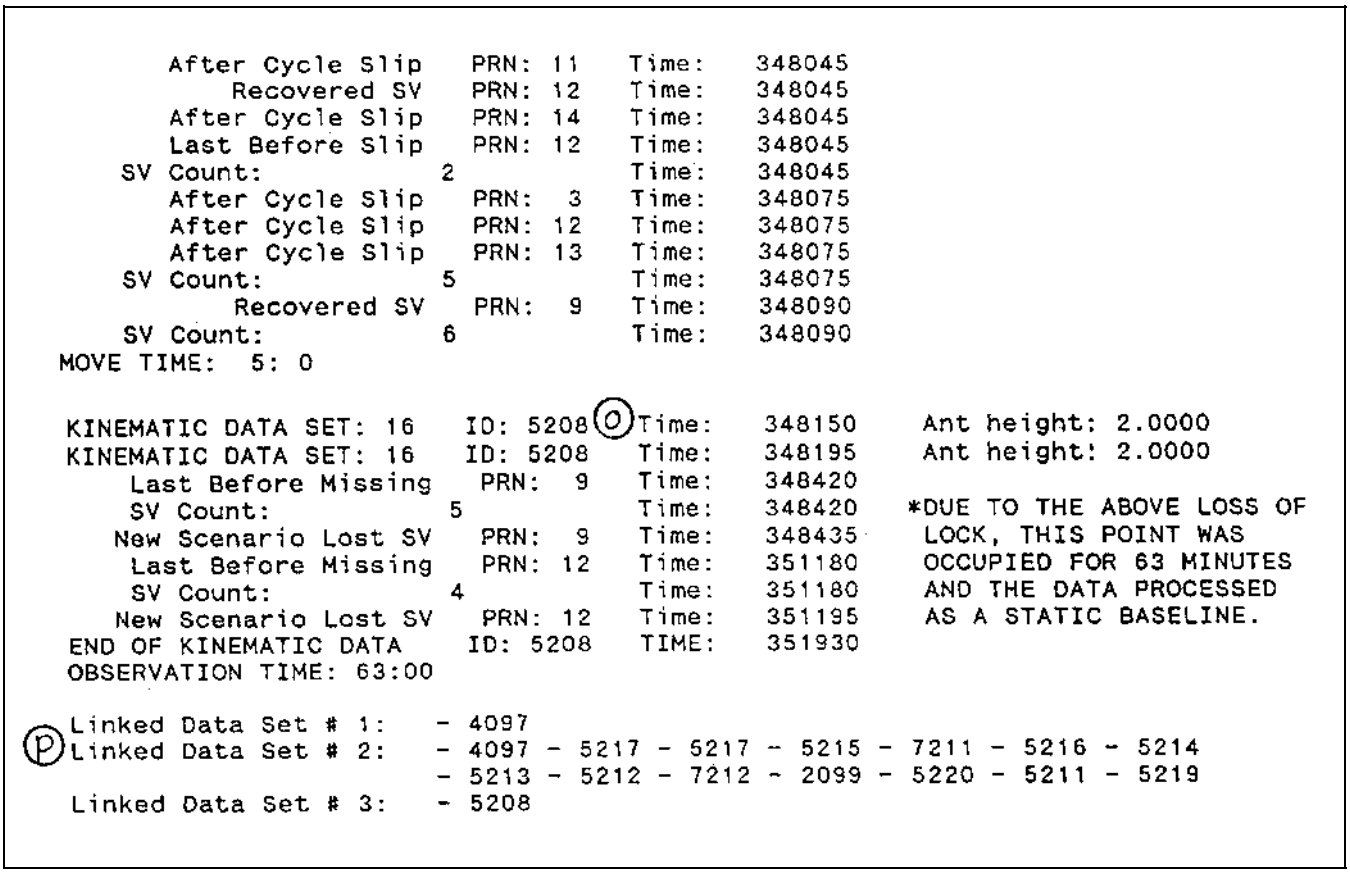
KINEMATIC DATA SET: 14   ID: 5211   Time:   347475    Ant height: 2.0000
END OF KINEMATIC DATA    ID: 5211   Time:   347535    Ant height: 2.0000
OBSERVATION TIME:  1:15

      Last Before Slip   PRN:  9   Time:   347730
   SV Count:          5             Time:   347730
      After Cycle Slip   PRN:  9   Time:   347760
   SV Count:          6             Time:   347760
MOVE TIME:  3:45

KINEMATIC DATA SET: 15   ID: 5219   Time:   347775    Ant height: 2.0000
END OF KINEMATIC DATA    ID: 5219   Time:   347835    Ant height: 2.0000
OBSERVATION TIME:  1:15

   Last Before Missing   PRN:  9   Time:   347895
      Last Before Slip   PRN:  3   Time:   347895
   SV Count:          4             Time:   347895
      After Cycle Slip   PRN:  3   Time:   347940
      Last Before Slip   PRN:  3   Time:   347940
      Last Before Slip   PRN: 11   Time:   347940
   SV Count:          3             Time:   347940
      After Cycle Slip   PRN: 11   Time:   347970
   SV Count:          4             Time:   347970
      Last Before Slip   PRN: 13   Time:   347986
   SV Count:          3             Time:   347986    *AT THIS POINT LOCK WAS
   Last Before Missing   PRN: 12   Time:   348000     NOT MAINTAINED ON AT
   SV Count:          2             Time:   348000     LEAST 4 SATELLITES.
      After Cycle Slip   PRN:  3   Time:   348015
      After Cycle Slip   PRN: 13   Time:   348015
      Last Before Slip   PRN:  3   Time:   348015
      Last Before Slip   PRN: 11   Time:   348015
      Last Before Slip   PRN: 13   Time:   348015
      Last Before Slip   PRN: 14   Time:   348015
   SV Count:          0             Time:   348015
      After Cycle Slip   PRN: 11   Time:   348045
         Recovered SV   PRN: 12   Time:   348045
      After Cycle Slip   PRN: 14   Time:   348045
      Last Before Slip   PRN: 12   Time:   348045
```

Figure E-16. (Sheet 4 of 6)

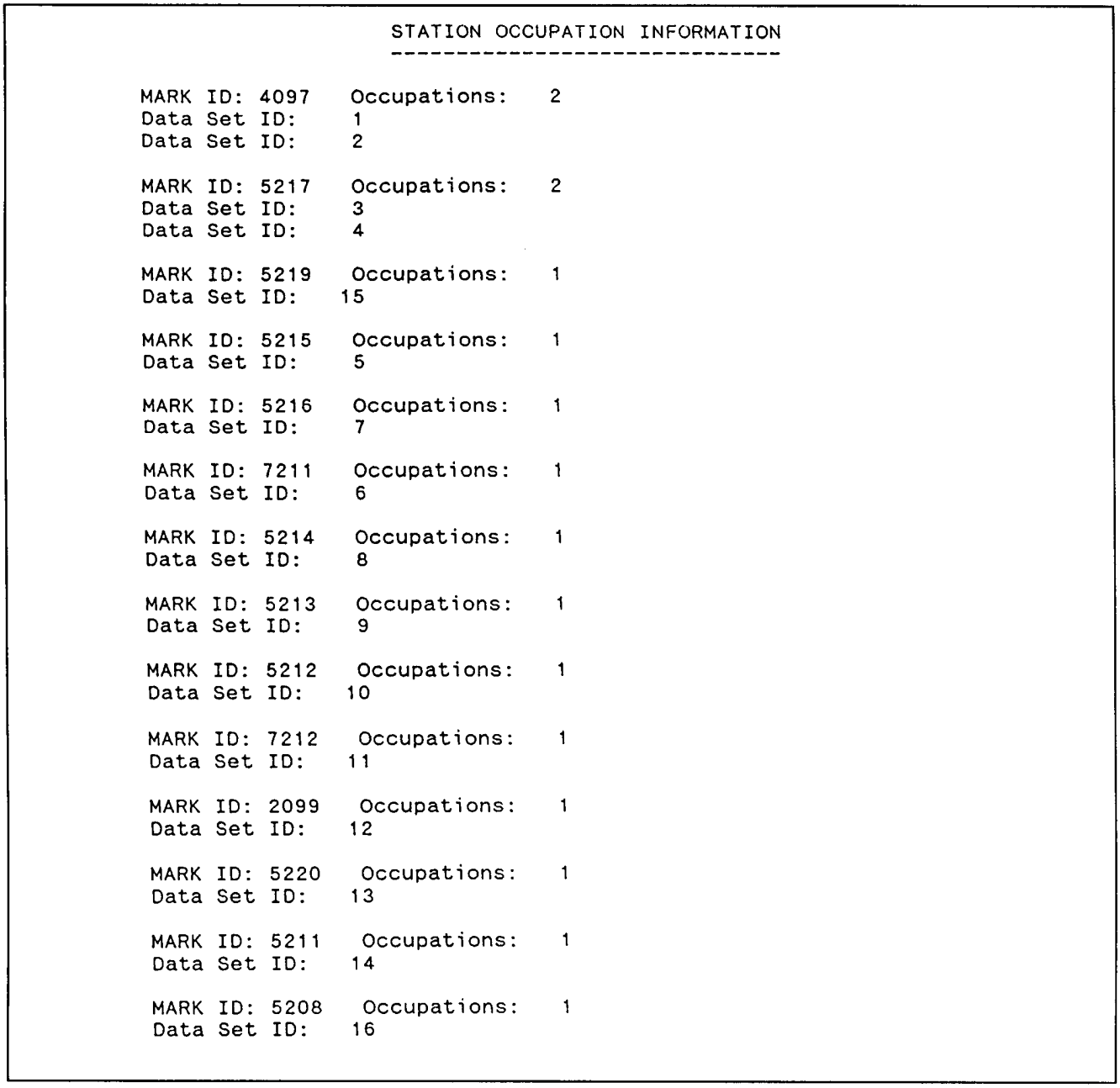


```
        After Cycle Slip   PRN: 11   Time:   348045
            Recovered SV   PRN: 12   Time:   348045
        After Cycle Slip   PRN: 14   Time:   348045
        Last Before Slip   PRN: 12   Time:   348045
     SV Count:           2            Time:   348045
        After Cycle Slip   PRN:  3   Time:   348075
        After Cycle Slip   PRN: 12   Time:   348075
        After Cycle Slip   PRN: 13   Time:   348075
     SV Count:           5            Time:   348075
            Recovered SV   PRN:  9   Time:   348090
     SV Count:           6            Time:   348090
  MOVE TIME:  5: 0

  KINEMATIC DATA SET: 16   ID: 5208 (O)Time:   348150   Ant height: 2.0000
  KINEMATIC DATA SET: 16   ID: 5208   Time:   348195   Ant height: 2.0000
      Last Before Missing   PRN:  9   Time:   348420
      SV Count:           5           Time:   348420   *DUE TO THE ABOVE LOSS OF
     New Scenario Lost SV   PRN:  9   Time:   348435    LOCK, THIS POINT WAS
      Last Before Missing   PRN: 12   Time:   351180    OCCUPIED FOR 63 MINUTES
      SV Count:           4           Time:   351180    AND THE DATA PROCESSED
     New Scenario Lost SV   PRN: 12   Time:   351195    AS A STATIC BASELINE.
  END OF KINEMATIC DATA    ID: 5208   TIME:   351930
  OBSERVATION TIME: 63:00

  Linked Data Set # 1:   - 4097
(P)Linked Data Set # 2:  - 4097 - 5217 - 5217 - 5215 - 7211 - 5216 - 5214
                         - 5213 - 5212 - 7212 - 2099 - 5220 - 5211 - 5219
  Linked Data Set # 3:   - 5208
```

Figure E-16. (Sheet 5 of 6)



STATION OCCUPATION INFORMATION

MARK ID: 4097 Occupations: 2
Data Set ID: 1
Data Set ID: 2

MARK ID: 5217 Occupations: 2
Data Set ID: 3
Data Set ID: 4

MARK ID: 5219 Occupations: 1
Data Set ID: 15

MARK ID: 5215 Occupations: 1
Data Set ID: 5

MARK ID: 5216 Occupations: 1
Data Set ID: 7

MARK ID: 7211 Occupations: 1
Data Set ID: 6

MARK ID: 5214 Occupations: 1
Data Set ID: 8

MARK ID: 5213 Occupations: 1
Data Set ID: 9

MARK ID: 5212 Occupations: 1
Data Set ID: 10

MARK ID: 7212 Occupations: 1
Data Set ID: 11

MARK ID: 2099 Occupations: 1
Data Set ID: 12

MARK ID: 5220 Occupations: 1
Data Set ID: 13

MARK ID: 5211 Occupations: 1
Data Set ID: 14

MARK ID: 5208 Occupations: 1
Data Set ID: 16

Figure E-16. (Sheet 6 of 6)

longer has lock on at least four satellites. The receiver CANNOT warn the roving receiver operator to reinitialize when a combination of the data from the rover and the data from the reference receiver no longer has lock on at least the same four satellites. If the survey is not reinitialized, the data collected subsequent to the loss of lock cannot be processed. Therefore, to ensure that all data collected can be processed, it is very important to chose a location for the reference receiver that has very little or no obstructions of the sky greater than 15 deg above the horizon.

c. If the stop-and-go data have to be manually post-processed, the rule of thumb is it takes twice as long to process the data as it does to collect it. In other words, if stop-and-go data were collected for 2 hr (including move time), it will take approximately 4 hr to post-process the data. If two reference receivers were utilized, it will take approximately 8 hr because twice as many baselines will have to be processed. Manual processing is very labor intensive because each cycle slip must be fixed before processing can continue. As stated previously, when a cycle slip occurs on a satellite, the integer cycle ambiguity for that satellite becomes unknown. When lock is recovered on the satellite, its integer cycle ambiguity must be once again resolved. The ambiguity is resolved by fixing the cycle slip. Missing satellite data are treated as a cycle slip and also require fixing during post-processing. Processing time varies with the number of cycle slips that occurred during the session; the fewer the cycle slips, the quicker the processing will proceed. The actual stepwise procedures of manual processing are beyond the scope of this manual and may vary depending on the software being used. The receiver manufacturer should be consulted for available post-processing training.

d. Some software has a batch mode for post-processing stop-and-go data. To save hours in post-processing time, this option should always be used when possible. Before stop-and-go data are collected, a thorough understanding of the batch processing requirements is strongly recommended. The field procedures used may be modified to meet the batch processing requirements.

e. All stop-and-go baselines observed on days 179 and 180 were manually post-processed. Figure E-17 shows a solution file for the baseline from the reference receiver at 3095 to the roving receiver at 4097. The file naming convention is different from that used for static solution files. Using the file name shown in Figure E-17 as an example, the convention for an eight-digit file name with a three-character extension is as follows.

40971795.k01

where

4097 = the ID of the station being occupied by the roving receiver

179 = the day of the year observations were recorded

5 = the last digit of the ID of the station being occupied by the reference receiver

k = part of extension denoting the file as kinematic

01 = part of extension that is incremented by one each time a station is reoccupied by the same rover on the same day

The solution output for stop-and-go baselines is very similar to the double-difference fixed solution for static baselines. Refer to the survey examples in Appendix D for an annotated output of a double-difference fixed solution.

f. Figure E-9 indicates stations HL-11, HL-13, HL-14, HL-15, HL-16, and HL-17 were occupied at different times by both rovers. Station HL-11 was occupied statically by rover 2 and kinematically by rover 1. The other five stations were occupied kinematically by both rovers. Table E-1 shows the repeatability of the values within baseline solutions comparing a static fixed solution to a stop-and-go kinematic solution and also two kinematic solutions processed from data obtained on different days. The comparisons are shown for baselines processed from both reference receivers. Analysis indicates the repeatability between the static and kinematic solutions was generally less than 20 ppm and that between the two kinematic solutions was about the same. The repeatability in the Y component was consistently the worst of the three components. The expected setup error of the range pole and bipod is greater than an optical plummet tribrach and tripod. This will affect the repeatability of two kinematic baselines, especially if the baselines are processed from data collected by different rovers. Relatively speaking, these results exceed in all cases Second-Order Class II precision requirements and in all cases but two, Second-Order Class I requirements.

```
                                                  07/10/89    13:45:42.30

                  TRIMBLE NAVIGATION, LTD
                   585 NORTH MARY AVENUE
                 SUNNYVALE, CALIFORNIA  94086
                          U.S.A.

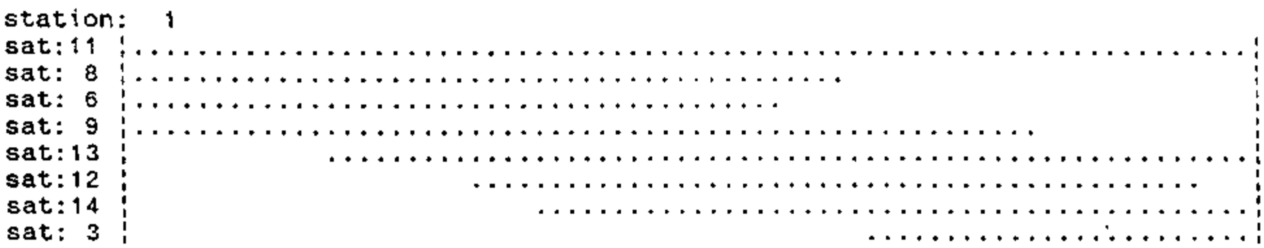
                      PROGRAM TRIMVEC
              GPS RELATIVE POSITIONING SOLUTION
                      VERSION 89.062MB

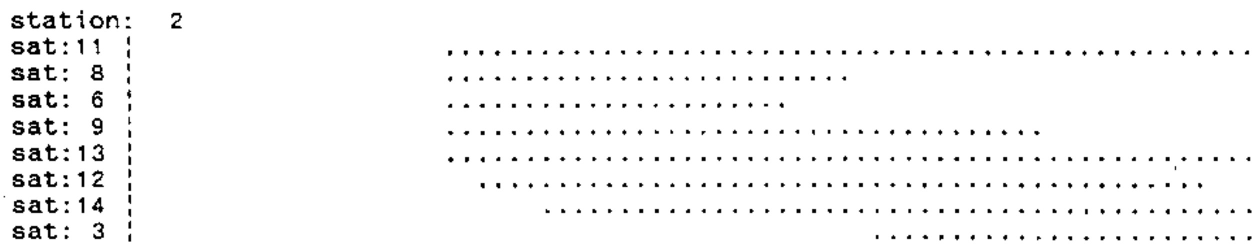
 File name: 40971795.k01
Coordinate system - WGS-84

Type solution:  Double difference
Value of L12: 1
  L1 solution

Start date/time: 1989/ 6/28     20:39:60.     day of year 179   tow    333600.
Stop  date/time: 1989/ 6/29      1:45: 0.     day of year 180   tow    351900.


Data available:
```






```
 Broadcast ephemeris file used: D:\179\30951791.eph
```

SATELLITE	IODE	HEALTH	WEEK NO.	TOW(sec)	URA(m)
11	184	0	494	349200.00	2.8
8	52	60	494	342000.00	32.0
6	27	0	494	342030.00	4.0
9	11	0	494	345600.00	2.8
13	69	0	494	349200.00	2.8
12	194	0	494	349200.00	4.0
14	7	0	494	349200.00	5.7
3	245	0	494	349230.00	2.0

Figure E-17. Kinematic solution output 3095 -> 4097 (Sheet 1 of 4)

```
Broadcast satellite clock correction values
   prn          af0                 af1                 af2                 toc
    11  -.3036004491D-03  -.5002220860D-11   .0000000000D+00   .3564D+06
     8  -.6075738929D-03  -.5923084245D-10  -.2775557562D-16   .3492D+06
     6  -.2873353660D-03  -.1796252036D-10   .0000000000D+00   .3492D+06
     9  -.3585955128D-03  -.1693933882D-10  -.2775557562D-16   .3528D+06
    13   .4193321802D-03   .2160049917D-11   .0000000000D+00   .3564D+06
    12   .8332398720D-03   .3751665645D-11   .0000000000D+00   .3564D+06
    14   .5646748468D-04   .5911715562D-11   .0000000000D+00   .3564D+06
     3   .1517958008D-03  -.1466560207D-10  -.2775557562D-16   .3564D+06


No message file for station  1

Origin of station 1 coordinates : User input

  STATION (mark)  1 3095

input data file  1 : D:\179\30951791.dat

 antenna height(m)     1.409

met values used:  pressure(mb)          1013.0
                  temperature(deg C)      20.0
                  relative humidity(%)    50.0

  x (m)          -185.143       lat  (dms)  N    34    59  52.56136
  y (m)      -5230645.165       elon (dms)  E   269    59  52.69908
  z (m)       3637739.935       wlon (dms)  W    90     0   7.30092
                                ht (m)           106.0190

No message file for station  2

  STATION (mark)  2 4097

input data file  1 : D:\179\40971792.dat

 antenna height(m)     1.963

met values used:  pressure(mb)          1013.0
                  temperature(deg C)      20.0
                  relative humidity(%)    50.0

  x (m)         -3140.364       lat  (dms)  N    34    56  53.54605
  y (m)      -5233794.156       elon (dms)  E   269    57  56.23770
  z (m)       3633210.847       wlon (dms)  W    90     2   3.76230
                                ht (m)            91.1048


Vector  1 originates at station 1 ends at station  2

 Vector Standard Deviations (m) :
                     dx              dy              dz

 Vector    1   .2740151D-02   .6418240D-02   .4906620D-02

 Vector correlation matrix :
                dx(01)     dy(01)     dz(01)

     dx(01)  1.0000000
     dy(01)  -.7430828  1.0000000
     dz(01)   .6281730  -.8394194  1.0000000
```

Figure E-17. (Sheet 2 of 4)

```
STATION 1 TO  STATION  2

slope distance (m)        6257.9635     sigma (m)      .0022

normal section azimuth (dms)  208 10 42.06
vertical angle (dms)            0 -9 53.01

 east(m)   north(m)   up(m)        -2955.109       -5516.259        -17.992

Delta lat(dms)     0   -2  59.01531
Delta lon(dms)     0   -1  56.46138
Delta ht(m)   -14.9142

 correlations for baseline  1:

                  dx          dy          dz        trop      bias 1      bias 2
              bias 3      bias 4      bias 5      bias 6      bias 7
        dx  1.0000000
        dy  -.7430828  1.0000000
        dz   .6281730  -.8394194  1.0000000
      trop   .0000000   .0000000   .0000000  1.0000000
    bias 1   .0000000   .0000000   .0000000   .0000000  1.0000000
    bias 2   .0000000   .0000000   .0000000   .0000000   .0000000  1.0000000
    bias 3   .0000000   .0000000   .0000000   .0000000   .0000000   .0000000
           1.0000000
    bias 4   .0000000   .0000000   .0000000   .0000000   .0000000   .0000000
             .0000000  1.0000000
    bias 5   .0000000   .0000000   .0000000   .0000000   .0000000   .0000000
             .0000000   .0000000  1.0000000
    bias 6   .0000000   .0000000   .0000000   .0000000   .0000000   .0000000
             .0000000   .0000000   .0000000  1.0000000
    bias 7   .0000000   .0000000   .0000000   .0000000   .0000000   .0000000
             .0000000   .0000000   .0000000   .0000000  1.0000000

                            Solution      Sigma
    dx (m)                 -2955.220        .003
    dy (m)                 -3148.991        .006
    dz (m)                 -4529.088        .005
  trop (%)                       .000       .000
 bias 1 (cycle)           9588533.000       .000
 bias 2 (cycle)           7281643.000       .000
 bias 3 (cycle)          -1603291.000       .000
 bias 4 (cycle)           4361315.000       .000
 bias 5 (cycle)           7690266.000       .000
 bias 6 (cycle)           9590043.000       .000
 bias 7 (cycle)                 .000       .000
 Rdop(norm to 60 sec) is       .295 (m/cycle)

 All Baseline Vectors:
                   dx(m)        dy(m)        dz(m)      dist(m)      dh(m)

From  1 To  2    -2955.220    -3148.991    -4529.088     6257.964    -14.914

  Interval between epochs (sec)  15.0
  Epoch increment     1
  Number of measurements used in solution    30
  Number of measurements rejected             0
  RMS (cycles)        .039
```

Figure E-17. (Sheet 3 of 4)

```
 Elevation mask (deg)      15.0
 Edit multiplier    3.5
 Modified Hopfield troposphere model used

Best tracking C/A code positions
Station  1
Pdop         2.4
  x (m)          -186.448       lat  (dms)  N    34     59  52.57129
  y (m)      -5230628.653       elon (dms)  E   269     59  52.64760
  z (m)       3637728.748       wlon (dms)  W    90      0   7.35241
                                ht (m)            86.0759
clock offset(s)           .50214212D-03
freq  offset(s/s)         .70699674D-09

 Code calibration(m)     Carrier calibration(m)
0 -  1           .1860                    .0003
0 -  2          -.0625                   -.0004
0 -  3          -.3057                   -.0005
0 -  4          -.2056                   -.0004
0 -  5         -2.9268                    .0000
0 -  6         -3.0786                   -.0001
0 -  7         -3.0503                   -.0005
0 -  8         -3.0967                   -.0006
0 -  9         -3.0073                   -.0005
Station  2
Pdop         2.5
  x (m)         -3142.263       lat  (dms)  N    34     56  53.56441
  y (m)      -5233776.319       elon (dms)  E   269     57  56.16241
  z (m)       3633199.073       wlon (dms)  W    90      2   3.83759
                                ht (m)            69.7407
clock offset(s)           .54571078D-03
freq  offset(s/s)        -.13415415D-09

 Code calibration(m)     Carrier calibration(m)
0 -  1           .0161                   -.0000
0 -  2          -.0752                   -.0004
0 -  3          -.0518                   -.0002
0 -  4          -.0840                   -.0005
0 -  5          -.1821                   -.0001
0 -  6          -.0806                    .0002
0 -  7          -.0786                   -.0003
0 -  8          -.0518                   -.0009
0 -  9          -.1606                   -.0009
```

Figure E-17. (Sheet 4 of 4)

Table E-1
Repeat Baseline Comparison

File Name	dX	dY	dZ
95111791.FIX	-1564.664	-1813.619	-2636.200
52111795.k01	-1564.666	-1813.590	-2636.214
Diff in meters	0.002	0.029	0.014
Diff in ppm	1.3	16.0	5.3
98111791.FIX	1757.126	1332.128	1902.257
52111798.k01	1757.113	1332.164	1902.226
Diff in meters	0.013	0.036	0.031
Diff in ppm	7.4	27.0	16.3
52131795.k01	-3572.835	-2316.710	-3359.378
52131805.k01	-3572.853	-2316.729	-3359.378
Diff in meters	0.018	0.050	0.029
Diff in ppm	5.0	21.6	8.6
52131795.k01	-251.058	829.025	1179.100
52131808.k01	-251.061	829.020	1179.111
Diff in meters	0.003	0.005	0.011
Diff in ppm	11.9	6.0	9.3

E-6. Adjustments

GEOLAB adjustment software was used to adjust this example survey. An IOB file was created by adding processed static and kinematic baselines from data obtained on days 179 and 180. Three separate network adjustments were performed using this file.

a. The first adjustment was run holding only USC&GS HUDGINS fixed in three dimensions. This adjustment provided a check of the internal precision of the GPS observations. A partial listing of the output for adjustment one is shown in Figure E-18. The data indicated the following:

(1) As shown on page 1 of the GEOLAB adjustment, the number of redundant measurements, or degrees of freedom, within the adjustment was high (87).

(2) As shown on page 31, the 2D and 1D station major semi-axis and minor semi-axis were at or less than the few-centimeter level.

(3) As shown on pages 32 and 33, the 2D and 1D relative error ellipses between survey points were at or less than the few-centimeter level. The precision of all baselines within the adjustment exceeded 30 ppm and 87 percent exceeded 10 ppm.

(4) As shown on page 28, the histogram indicates some of the residuals were higher than anticipated. These higher residuals fell outside of the bell-shaped curve.

(5) As shown on page 29, the estimated variance factor in the statistics summary is somewhat high. Higher residuals and variance factors than seen with static data can be expected when adjusting stop-and-go baselines. Although some high residual values exist in the adjustment, the precision of all baselines relative to their length are within Second-Order Class II requirements and 87 percent are within First-Order requirements. Longer occupation times may help to improve some of the statistical values and baseline precisions if higher orders of accuracy are desired.

b. The second adjustment was run holding USC&GS HUDGINS fixed in three dimensions and P-13-2-89 fixed in two dimensions. This adjustment was performed to obtain the final adjusted horizontal positions of all of the photo control points occupied using GPS. After obtaining the adjusted positions from GEOLAB, terrestrial traverse computations were performed to obtain positions on the remaining photo control points. A partial listing of the output for adjustment two is shown in Figure E-19. Here, the statistical values and relative errors increased only slightly compared to adjustment one after holding a second point fixed. The relative precision of all baselines in the adjustment still exceed Second Order Class II requirements.

c. The third and final adjustment was ran holding USC&GS HUDGINS fixed in three dimensions and S 22 1974, HL-1 and HL-20 fixed in one dimension. All heights fixed in the adjustment were orthometric or relative to the geoid. If elevations relative to the geoid are desired, a separate vertical adjustment is required holding only one point fixed horizontally. Horizontal and vertical adjustments should not be combined because precisions in the horizontal plane will affect precisions in the vertical plane and vice versa. A partial listing of the output for adjustment three is shown in Figure E-20. Page 33 of the output indicates that the 1D confidence region for each station in the adjustment is less than 0.1 m.

E-7. Project Summary

Positions in 3D were developed for 23 photo control points as well as 2D positions for two new Type A monuments.

a. The field work for the survey was completed in approximately 35 hr with a task breakdown as follows.

(1) 8 hr for presurvey reconnaissance, 2-man crew.

```
                U.S. ARMY CORPS OF ENGINEERS - MEMPHIS DISTRICT
          HORN LAKE CREEK PHOTO CONTROL - GPS STOP & GO KINEMATIC SURVEY
A=  6378137.000 B=  6356752.314 X0=       0.000 Y0=       0.000 Z0=       0.000
PREPARE:

09:34:43 - Tuesday, October 09, 1990

Input from:    <GPS7K_1.iob>
Output to:     <GPS7K_1.LST>

PREPARE successfully completed.

GeoLab - V1.91S, (C) 1985/86/87/88/89 BitWise Ideas Inc. [103208976]  Page    0
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                U.S. ARMY CORPS OF ENGINEERS - MEMPHIS DISTRICT
          HORN LAKE CREEK PHOTO CONTROL - GPS STOP & GO KINEMATIC SURVEY
A=  6378137.000 B=  6356752.314 X0=       0.000 Y0=       0.000 Z0=       0.000
GETUP:
```

PARAMETERS		OBSERVATIONS	
Description	Number	Description	Number
All Stations	24	Directions	0
Fixed Stations	1	Distances	0
Free 3-D Stations	23	Azimuths	0
Free 2-D Stations	0	Vertical Angles	0
Free 1-D Stations	0	Zenithal Angles	0
Coord. Parameters	69	Angles	0
Astro. Latitudes	0	Heights	0
Astro. Longitudes	0	Height Differences	0
Geoid Records	0	Auxiliary Params.	0
All Aux. Pars.	0	2-D Coords.	0
Direction Pars.	0	2-D Coord. Diffs.	0
Scale Parameters	0	3-D Coords.	0
Constant Pars.	0	3-D Coord. Diffs.	156
Rotation Pars.	0		
Translation Pars.	0		
Total Parameters	69	Total Observations	156
Degrees of Freedom =	87		

```
GeoLab - V1.91S, (C) 1985/86/87/88/89 BitWise Ideas Inc. [103208976]  Page    1
```

Figure E-18. Minimally constrained horizontal adjustment (Sheet 1 of 6)

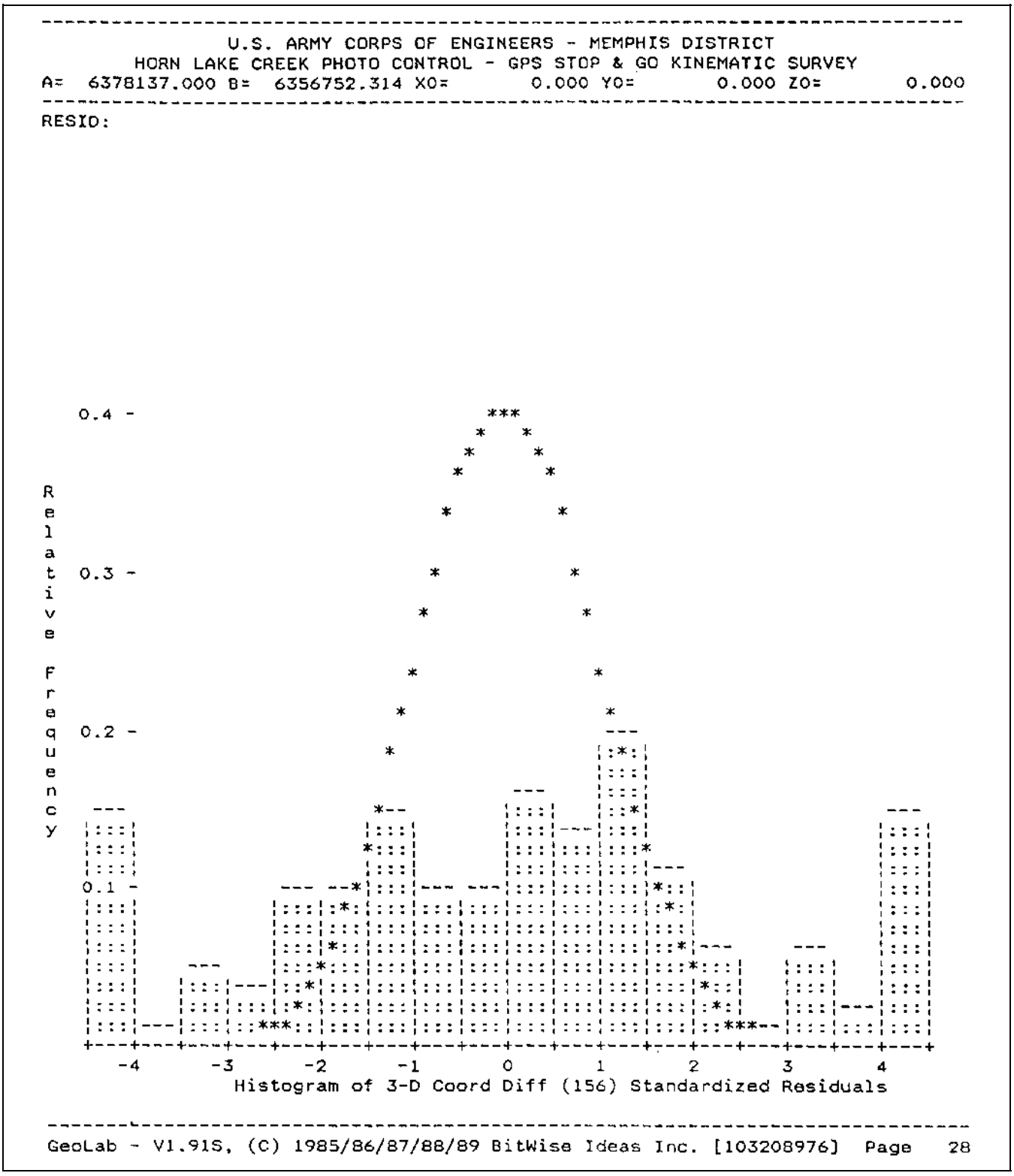

Figure E-18. (Sheet 2 of 6)

```
                U.S. ARMY CORPS OF ENGINEERS - MEMPHIS DISTRICT
          HORN LAKE CREEK PHOTO CONTROL - GPS STOP & GO KINEMATIC SURVEY
A=  6378137.000 B=  6356752.314 XO=        0.000 YO=        0.000 ZO=        0.000
RESID:

                    S T A T I S T I C S     S U M M A R Y

     Residual Critical Value Type                          Tau Max
     Residual Critical Value                                3.6542
     Convergence Criterion                                0.001000
     Final Iteration Counter Value                               2
     Confidence Level Used                                95.0000
     Number of Flagged Residuals                                29
     Estimated Variance Factor                              9.2151
     Number of Degrees of Freedom                               87

                  Chi-Square Test on the Variance Factor:

                  6.9901e+000  <  1.0000  <  1.2708e+001  ?

    !!!!!!!!!!!!!!!!!!!!!!!!   THE TEST FAILS   !!!!!!!!!!!!!!!!!!!!!!!!

RESID successfully completed.

GeoLab - V1.91S, (C) 1985/86/87/88/89 BitWise Ideas Inc. [103208976]  Page   29
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Figure E-18. (Sheet 3 of 6)

U.S. ARMY CORPS OF ENGINEERS - MEMPHIS DISTRICT
HORN LAKE CREEK PHOTO CONTROL - GPS STOP & GO KINEMATIC SURVEY
A= 6378137.000 B= 6356752.314 X0= 0.000 Y0= 0.000 Z0= 0.000

ELLIPSE:

2-D AND 1-D STATION CONFIDENCE REGIONS (95.000 %):

IDENT.	MAJOR SEMI-AXIS	MINOR SEMI-AXIS	AZ(MAJ)	VERTICAL
4098	0.0037	0.0030	145.07	0.0084
4097	0.0111	0.0098	104.55	0.0231
5211	0.0086	0.0079	76.51	0.0167
5221	0.0229	0.0137	4.04	0.0536
5208	0.0353	0.0135	1.88	0.0593
5213	0.0079	0.0059	114.15	0.0117
2099	0.0190	0.0128	23.44	0.0402
5212	0.0227	0.0085	9.19	0.0985
5214	0.0139	0.0078	153.79	0.0406
5215	0.0076	0.0055	160.93	0.0217
5216	0.0056	0.0035	157.21	0.0196
5217	0.0152	0.0107	143.90	0.0344
5219	0.0167	0.0103	11.22	0.0322
5220	0.0143	0.0096	17.16	0.0295
7212	0.0102	0.0073	24.15	0.0219
5222	0.0069	0.0057	87.95	0.0139
5224	0.0150	0.0122	94.27	0.0321
5223	0.0078	0.0063	101.33	0.0176
5209	0.0074	0.0060	66.59	0.0113
5218	0.0123	0.0097	128.12	0.0201
5206	0.0116	0.0086	142.23	0.0263
5201	0.0125	0.0082	28.16	0.0260
5203	0.0115	0.0044	8.95	0.0540

Figure E-18. (Sheet 4 of 6)

U.S. ARMY CORPS OF ENGINEERS - MEMPHIS DISTRICT
HORN LAKE CREEK PHOTO CONTROL - GPS STOP & GO KINEMATIC SURVEY
A= 6378137.000 B= 6356752.314 X0= 0.000 Y0= 0.000 Z0= 0.000

ELLIPSE:

2-D AND 1-D RELATIVE STATION CONFIDENCE REGIONS (95.000 %):

FROM	TO	MAJ.SEMI	MIN.SEMI	AZ(MAJ)	VERTICAL	SPATIAL DIST.	PRECISION
4098	4097	0.0110	0.0097	99.22	0.0227	366.6975	29.965 PPM
4098	5211	0.0082	0.0071	72.51	0.0145	2912.1464	2.824 PPM
4098	5221	0.0231	0.0140	3.76	0.0541	4613.1049	5.003 PPM
4098	5208	0.0353	0.0132	1.93	0.0591	2733.5199	12.901 PPM
4098	2099	0.0188	0.0124	23.86	0.0395	2209.5900	8.528 PPM
4098	5212	0.0226	0.0081	9.40	0.0983	2184.0854	10.334 PPM
4098	5214	0.0140	0.0078	153.61	0.0398	1476.6279	9.461 PPM
4098	5215	0.0079	0.0057	158.56	0.0214	801.5978	9.828 PPM
4098	5216	0.0060	0.0039	154.86	0.0183	542.8320	10.996 PPM
4098	5217	0.0151	0.0106	143.88	0.0340	661.3902	22.792 PPM
4098	5219	0.0168	0.0104	11.02	0.0324	2891.5861	5.799 PPM
4098	5220	0.0139	0.0091	18.11	0.0286	2566.7333	5.434 PPM
4098	7212	0.0097	0.0064	26.24	0.0204	2016.1771	4.824 PPM
4098	5222	0.0070	0.0059	89.23	0.0142	4430.4221	1.574 PPM
4098	5224	0.0150	0.0122	94.28	0.0321	5477.8680	2.742 PPM
4098	5213	0.0076	0.0056	114.08	0.0113	1463.0776	5.162 PPM
4098	5223	0.0080	0.0065	102.72	0.0180	5905.2055	1.354 PPM
4098	5209	0.0078	0.0067	68.72	0.0132	2151.8382	3.631 PPM
4098	5218	0.0119	0.0094	127.14	0.0189	1886.0709	6.326 PPM
4098	5206	0.0118	0.0088	142.32	0.0268	3467.4965	3.412 PPM
4098	5203	0.0114	0.0041	9.23	0.0538	5895.6948	1.932 PPM
4098	5201	0.0127	0.0084	27.81	0.0264	6501.9484	1.947 PPM
4098	3095	0.0037	0.0030	145.07	0.0084	6444.1890	0.580 PPM
4097	3095	0.0111	0.0098	104.55	0.0231	6257.9628	1.776 PPM
3095	5211	0.0086	0.0079	76.51	0.0167	3561.8762	2.428 PPM
3095	5208	0.0353	0.0135	1.88	0.0593	3860.2180	9.155 PPM
3095	5221	0.0229	0.0137	4.04	0.0536	2049.7519	11.170 PPM
3095	5213	0.0079	0.0059	114.15	0.0117	5423.8080	1.456 PPM
3095	2099	0.0190	0.0128	23.44	0.0402	6228.3592	3.056 PPM
3095	5212	0.0227	0.0085	9.19	0.0985	4670.3247	4.871 PPM
3095	5214	0.0139	0.0078	153.79	0.0406	5123.7279	2.718 PPM
3095	5215	0.0076	0.0055	160.93	0.0217	6286.9779	1.201 PPM
3095	5216	0.0056	0.0035	157.21	0.0196	6093.8864	0.915 PPM
3095	5217	0.0152	0.0107	143.90	0.0344	6657.5099	2.288 PPM
3095	5219	0.0167	0.0103	11.22	0.0322	3553.0160	4.696 PPM
3095	5220	0.0143	0.0096	17.16	0.0295	4130.2034	3.452 PPM
3095	7212	0.0102	0.0073	24.15	0.0219	5986.6100	1.705 PPM
3095	5222	0.0069	0.0057	87.95	0.0139	2948.5824	2.328 PPM
3095	5224	0.0150	0.0122	94.27	0.0321	2553.4890	5.881 PPM
3095	5223	0.0078	0.0063	101.33	0.0176	1964.3998	3.985 PPM
3095	5209	0.0074	0.0060	66.59	0.0113	4497.4302	1.649 PPM
3095	5218	0.0123	0.0097	128.12	0.0201	4558.2365	2.702 PPM
3095	5206	0.0116	0.0086	142.23	0.0263	4289.4530	2.703 PPM
3095	5201	0.0125	0.0082	28.16	0.0260	7706.4120	1.628 PPM

Figure E-18. (Sheet 5 of 6)

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                U.S. ARMY CORPS OF ENGINEERS - MEMPHIS DISTRICT
          HORN LAKE CREEK PHOTO CONTROL - GPS STOP & GO KINEMATIC SURVEY
A=  6378137.000 B=  6356752.314 XO=       0.000 YO=       0.000 ZO=       0.000

ELLIPSE:

2-D AND 1-D RELATIVE STATION CONFIDENCE REGIONS ( 95.000 %):

FROM     TO       MAJ.SEMI MIN.SEMI AZ(MAJ) VERTICAL SPATIAL DIST.    PRECISION
-------- -------- -------- -------- ------- -------- ------------- ------------
3095     5203       0.0115   0.0044    8.95   0.0540     6734.0519    1.709 PPM

ELLIPSE successfully completed.
09:40:34 - Tuesday, October 09, 1990

GeoLab - V1.91S, (C) 1985/86/87/88/89 BitWise Ideas Inc. [103208976]  Page   33
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Figure E-18. (Sheet 6 of 6)

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                U.S. ARMY CORPS OF ENGINEERS - MEMPHIS DISTRICT
          HORN LAKE CREEK PHOTO CONTROL - GPS STOP & GO KINEMATIC SURVEY
A=  6378137.000 B=  6356752.314 X0=       0.000 Y0=       0.000 Z0=       0.000
PREPARE:

10:00:35 - Tuesday, October 09, 1990

Input from:    <GPS7K_2.iob>
Output to:     <GPS7K_2.LST>

PREPARE successfully completed.


GeoLab - V1.91S, (C) 1985/86/87/88/89 BitWise Ideas Inc. [103208976]  Page    0


                U.S. ARMY CORPS OF ENGINEERS - MEMPHIS DISTRICT
          HORN LAKE CREEK PHOTO CONTROL - GPS STOP & GO KINEMATIC SURVEY
A=  6378137.000 B=  6356752.314 X0=       0.000 Y0=       0.000 Z0=       0.000
GETUP:
```

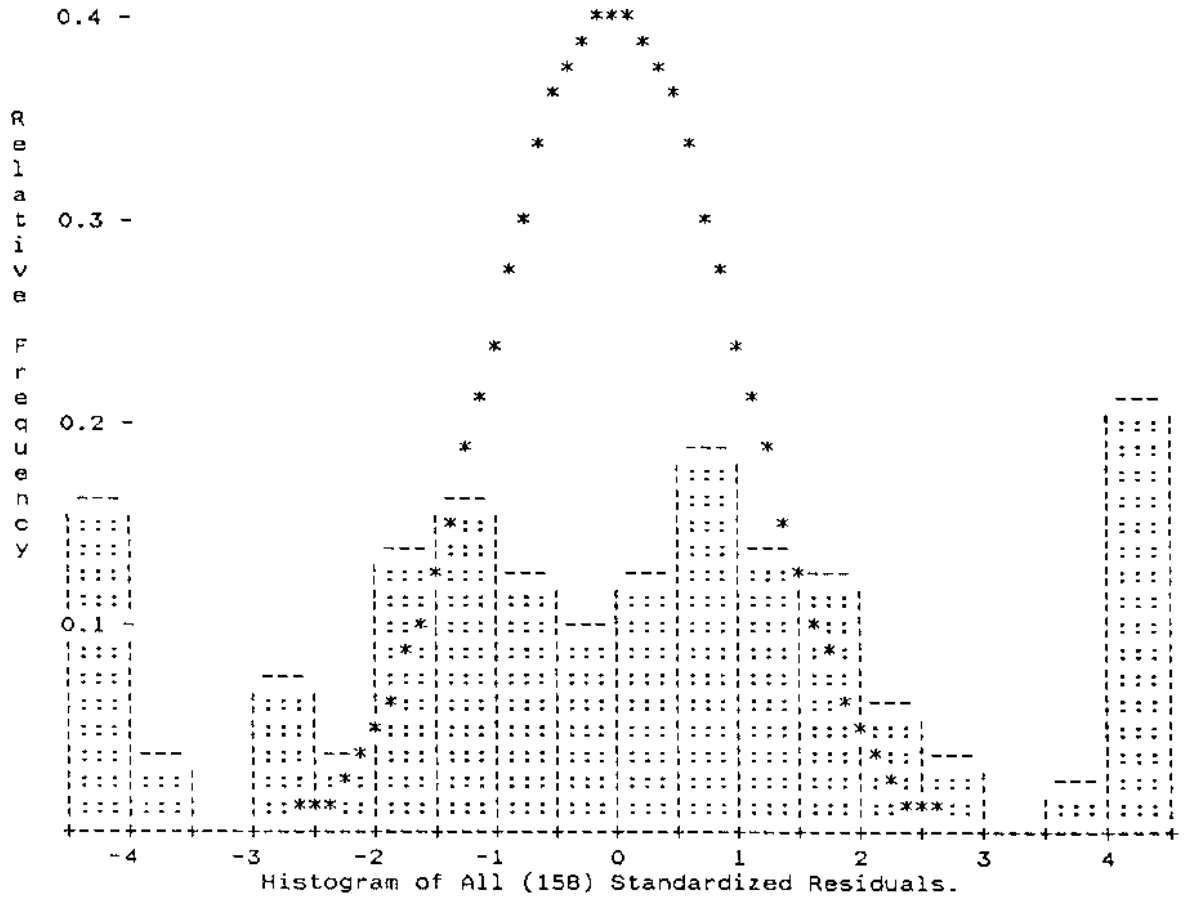
PARAMETERS		OBSERVATIONS	
Description	Number	Description	Number
All Stations	24	Directions	0
Fixed Stations	1	Distances	0
Free 3-D Stations	23	Azimuths	0
Free 2-D Stations	0	Vertical Angles	0
Free 1-D Stations	0	Zenithal Angles	0
Coord. Parameters	69	Angles	0
Astro. Latitudes	0	Heights	0
Astro. Longitudes	0	Height Differences	0
Geoid Records	0	Auxiliary Params.	0
All Aux. Pars.	0	2-D Coords.	2
Direction Pars.	0	2-D Coord. Diffs.	0
Scale Parameters	0	3-D Coords.	0
Constant Pars.	0	3-D Coord. Diffs.	156
Rotation Pars.	0		
Translation Pars.	0		
Total Parameters	69	Total Observations	158
Degrees of Freedom =	89		

```
GeoLab - V1.91S, (C) 1985/86/87/88/89 BitWise Ideas Inc. [103208976]  Page    1
```

Figure E-19. Fully constrained horizontal adjustment (Sheet 1 of 6)

U.S. ARMY CORPS OF ENGINEERS - MEMPHIS DISTRICT
HORN LAKE CREEK PHOTO CONTROL - GPS STOP & GO KINEMATIC SURVEY
A= 6378137.000 B= 6356752.314 XO= 0.000 YO= 0.000 ZO= 0.000

RESID:



GeoLab - V1.91S, (C) 1985/86/87/88/89 BitWise Ideas Inc. [103208976] Page 30

Figure E-19. (Sheet 2 of 6)

```
                U.S. ARMY CORPS OF ENGINEERS - MEMPHIS DISTRICT
          HORN LAKE CREEK PHOTO CONTROL - GPS STOP & GO KINEMATIC SURVEY
A=  6378137.000 B=  6356752.314 XO=       0.000 YO=       0.000 ZO=       0.000
RESID:

                    S T A T I S T I C S    S U M M A R Y

     Residual Critical Value Type                    Tau Max
     Residual Critical Value                          3.6597
     Convergence Criterion                         0.001000
     Final Iteration Counter Value                        2
     Confidence Level Used                          95.0000
     Number of Flagged Residuals                         35
     Estimated Variance Factor                      13.2102
     Number of Degrees of Freedom                        89

                  Chi-Square Test on the Variance Factor:

                  1.0050e+001  <  1.0000  <  1.8146e+001  ?

    !!!!!!!!!!!!!!!!!!!!!!!!   THE TEST FAILS   !!!!!!!!!!!!!!!!!!!!!!!!

RESID successfully completed.

GeoLab - V1.91S, (C) 1985/86/87/88/89 BitWise Ideas Inc. [103208976]  Page   31
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Figure E-19. (Sheet 3 of 6)

U.S. ARMY CORPS OF ENGINEERS - MEMPHIS DISTRICT
HORN LAKE CREEK PHOTO CONTROL - GPS STOP & GO KINEMATIC SURVEY
A= 6378137.000 B= 6356752.314 X0= 0.000 Y0= 0.000 Z0= 0.000

ELLIPSE:

2-D AND 1-D STATION CONFIDENCE REGIONS (95.000 %):

IDENT.	MAJOR SEMI-AXIS	MINOR SEMI-AXIS	AZ(MAJ)	VERTICAL
4098	0.0040	0.0034	145.07	0.0099
4097	0.0133	0.0117	103.56	0.0276
5211	0.0103	0.0093	74.85	0.0199
5221	0.0274	0.0165	4.04	0.0642
5208	0.0423	0.0161	1.90	0.0710
5213	0.0094	0.0070	113.66	0.0140
2099	0.0228	0.0152	23.58	0.0481
5212	0.0272	0.0101	9.26	0.1179
5214	0.0167	0.0093	153.80	0.0486
5215	0.0090	0.0065	160.93	0.0259
5216	0.0066	0.0042	157.23	0.0235
5217	0.0182	0.0128	143.89	0.0411
5219	0.0200	0.0123	11.25	0.0385
5220	0.0170	0.0114	17.47	0.0353
7212	0.0121	0.0085	24.83	0.0262
5222	0.0082	0.0068	87.45	0.0166
5224	0.0180	0.0146	94.13	0.0385
5223	0.0093	0.0075	101.03	0.0210
5209	0.0089	0.0072	66.56	0.0136
5218	0.0147	0.0116	127.81	0.0241
5206	0.0139	0.0103	142.23	0.0315
5201	0.0150	0.0098	28.21	0.0311
5203	0.0137	0.0052	9.10	0.0646

Figure E-19. (Sheet 4 of 6)

U.S. ARMY CORPS OF ENGINEERS - MEMPHIS DISTRICT
HORN LAKE CREEK PHOTO CONTROL - GPS STOP & GO KINEMATIC SURVEY
A= 6378137.000 B= 6356752.314 XO= 0.000 YO= 0.000 ZO= 0.000

ELLIPSE:

2-D AND 1-D RELATIVE STATION CONFIDENCE REGIONS (95.000 %):

FROM	TO	MAJ.SEMI	MIN.SEMI	AZ(MAJ)	VERTICAL	SPATIAL DIST.	PRECISION
4098	4097	0.0131	0.0116	99.26	0.0271	366.6987	35.831 PPM
4098	5211	0.0098	0.0085	72.49	0.0174	2912.1468	3.381 PPM
4098	5221	0.0276	0.0167	3.85	0.0647	4613.1075	5.981 PPM
4098	5208	0.0422	0.0159	1.94	0.0707	2733.5206	15.445 PPM
4098	2099	0.0226	0.0149	23.87	0.0473	2209.5901	10.210 PPM
4098	5212	0.0270	0.0096	9.41	0.1176	2184.0857	12.372 PPM
4098	5214	0.0167	0.0093	153.65	0.0477	1476.6292	11.304 PPM
4098	5215	0.0093	0.0068	159.03	0.0256	801.5979	11.644 PPM
4098	5216	0.0070	0.0045	155.32	0.0219	542.8330	12.936 PPM
4098	5217	0.0180	0.0127	143.88	0.0407	661.3897	27.271 PPM
4098	5219	0.0200	0.0124	11.12	0.0388	2891.5879	6.933 PPM
4098	5220	0.0167	0.0109	18.11	0.0342	2566.7336	6.506 PPM
4098	7212	0.0116	0.0077	26.24	0.0244	2016.1771	5.776 PPM
4098	5222	0.0083	0.0070	88.31	0.0170	4430.4238	1.873 PPM
4098	5224	0.0180	0.0146	94.14	0.0385	5477.8695	3.280 PPM
4098	5213	0.0090	0.0067	113.86	0.0135	1463.0782	6.169 PPM
4098	5223	0.0095	0.0077	101.99	0.0215	5905.2073	1.611 PPM
4098	5209	0.0093	0.0078	67.94	0.0157	2151.8403	4.314 PPM
4098	5218	0.0143	0.0112	127.13	0.0226	1886.0714	7.572 PPM
4098	5206	0.0141	0.0105	142.28	0.0321	3467.4980	4.065 PPM
4098	5203	0.0136	0.0049	9.29	0.0644	5895.6951	2.311 PPM
4098	5201	0.0151	0.0100	27.97	0.0315	6501.9487	2.326 PPM
4098	3095	0.0040	0.0034	145.07	0.0099	6444.1920	0.620 PPM
4097	3095	0.0133	0.0117	103.56	0.0276	6257.9643	2.119 PPM
3095	5211	0.0103	0.0093	74.85	0.0199	3561.8789	2.885 PPM
3095	5208	0.0423	0.0161	1.90	0.0710	3860.2203	10.956 PPM
3095	5221	0.0274	0.0165	4.04	0.0642	2049.7523	13.373 PPM
3095	5213	0.0094	0.0070	113.66	0.0140	5423.8102	1.726 PPM
3095	2099	0.0228	0.0152	23.58	0.0481	6228.3617	3.653 PPM
3095	5212	0.0272	0.0101	9.26	0.1179	4670.3272	5.823 PPM
3095	5214	0.0167	0.0093	153.80	0.0486	5123.7294	3.250 PPM
3095	5215	0.0090	0.0065	160.93	0.0259	6286.9790	1.435 PPM
3095	5216	0.0066	0.0042	157.23	0.0235	6093.8876	1.090 PPM
3095	5217	0.0182	0.0128	143.89	0.0411	6657.5119	2.732 PPM
3095	5219	0.0200	0.0123	11.25	0.0385	3553.0171	5.620 PPM
3095	5220	0.0170	0.0114	17.47	0.0353	4130.2059	4.118 PPM
3095	7212	0.0121	0.0085	24.83	0.0262	5986.6129	2.026 PPM
3095	5222	0.0082	0.0068	87.45	0.0166	2948.5833	2.778 PPM
3095	5224	0.0180	0.0146	94.13	0.0385	2553.4896	7.035 PPM
3095	5223	0.0093	0.0075	101.03	0.0210	1964.4001	4.759 PPM
3095	5209	0.0089	0.0072	66.56	0.0136	4497.4308	1.974 PPM
3095	5218	0.0147	0.0116	127.81	0.0241	4558.2390	3.215 PPM
3095	5206	0.0139	0.0103	142.23	0.0315	4289.4539	3.234 PPM
3095	5201	0.0150	0.0098	28.21	0.0311	7706.4128	1.948 PPM

Figure E-19. (Sheet 5 of 6)

```
                U.S. ARMY CORPS OF ENGINEERS - MEMPHIS DISTRICT
        HORN LAKE CREEK PHOTO CONTROL - GPS STOP & GO KINEMATIC SURVEY
A=  6378137.000 B=  6356752.314 X0=       0.000 Y0=       0.000 Z0=       0.000
-------------------------------------------------------------------------------

ELLIPSE:

2-D AND 1-D RELATIVE STATION CONFIDENCE REGIONS ( 95.000 %):
-----------------------------------------------------
FROM     TO       MAJ.SEMI MIN.SEMI AZ(MAJ) VERTICAL SPATIAL DIST.    PRECISION
-------- -------- -------- -------- ------- -------- ------------- ------------
3095     5203       0.0137   0.0052    9.10   0.0646     6734.0532    2.040 PPM

ELLIPSE successfully completed.
10:06:34 - Tuesday, October 09, 1990

-------------------------------------------------------------------------------
GeoLab - V1.91S, (C) 1985/86/87/88/89 BitWise Ideas Inc. [103208976]  Page   35
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Figure E-19. (Sheet 6 of 6)

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                U.S. ARMY CORPS OF ENGINEERS - MEMPHIS DISTRICT
          HORN LAKE CREEK PHOTO CONTROL - GPS STOP & GO KINEMATIC SURVEY
A=  6378137.000 B=  6356752.314 X0=       0.000 Y0=       0.000 Z0=       0.000

PREPARE:

10:29:30 - Tuesday, October 09, 1990

Input from:    <GPS7K_3.iob>
Output to:     <GPS7K_3.LST>

PREPARE successfully completed.

GeoLab - V1.91S, (C) 1985/86/87/88/89 BitWise Ideas Inc. [103208976]  Page    0
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                U.S. ARMY CORPS OF ENGINEERS - MEMPHIS DISTRICT
          HORN LAKE CREEK PHOTO CONTROL - GPS STOP & GO KINEMATIC SURVEY
A=  6378137.000 B=  6356752.314 X0=       0.000 Y0=       0.000 Z0=       0.000

GETUP:
```

PARAMETERS		OBSERVATIONS	
Description	Number	Description	Number
All Stations	24	Directions	0
Fixed Stations	1	Distances	0
Free 3-D Stations	23	Azimuths	0
Free 2-D Stations	0	Vertical Angles	0
Free 1-D Stations	0	Zenithal Angles	0
Coord. Parameters	69	Angles	0
Astro. Latitudes	0	Heights	3
Astro. Longitudes	0	Height Differences	0
Geoid Records	0	Auxiliary Params.	0
All Aux. Pars.	0	2-D Coords.	0
Direction Pars.	0	2-D Coord. Diffs.	0
Scale Parameters	0	3-D Coords.	0
Constant Pars.	0	3-D Coord. Diffs.	156
Rotation Pars.	0		
Translation Pars.	0		
Total Parameters	69	Total Observations	159
Degrees of Freedom =	90		

```
GeoLab - V1.91S, (C) 1985/86/87/88/89 BitWise Ideas Inc. [103208976]  Page    1
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Figure E-20. Fully constrained vertical adjustment (Sheet 1 of 6)

U.S. ARMY CORPS OF ENGINEERS - MEMPHIS DISTRICT
HORN LAKE CREEK PHOTO CONTROL - GPS STOP & GO KINEMATIC SURVEY
A= 6378137.000 B= 6356752.314 XO= 0.000 YO= 0.000 ZO= 0.000

RESID:

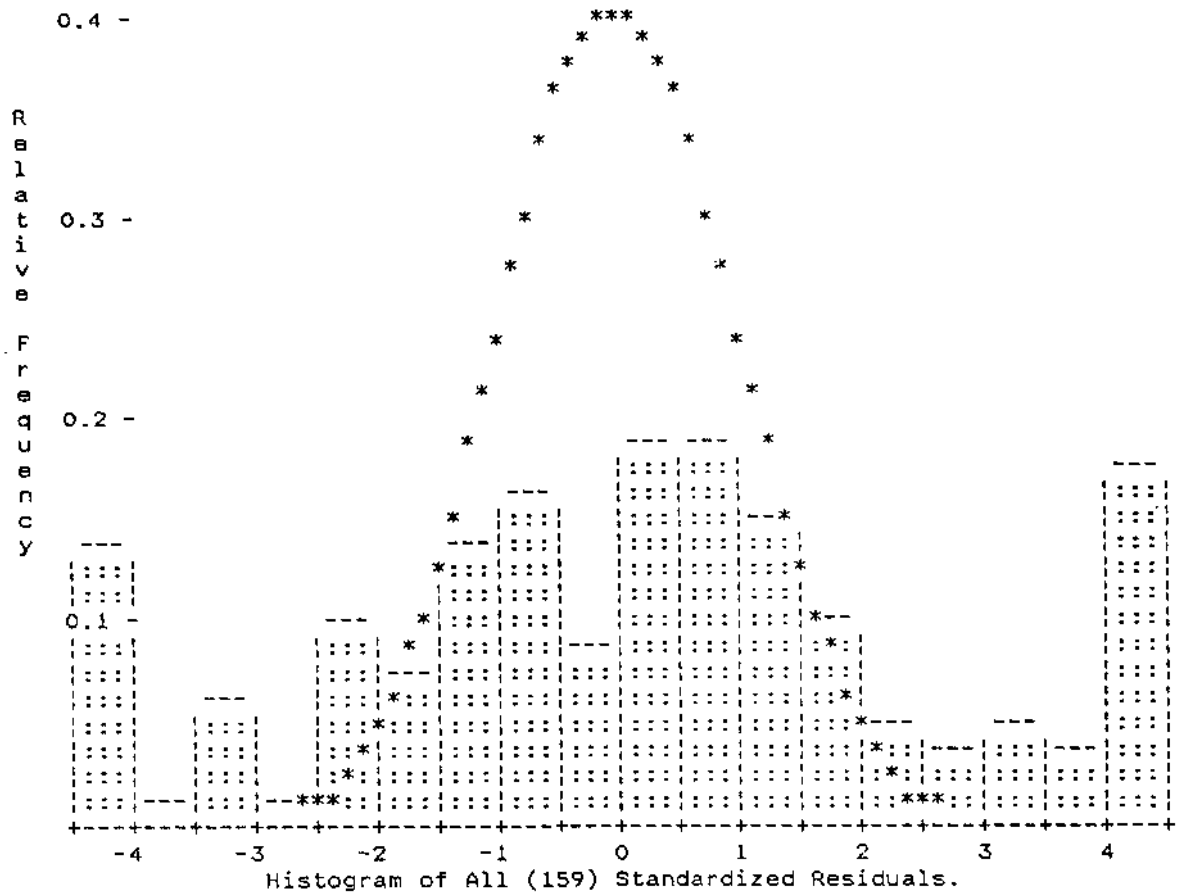

Figure E-20. (Sheet 2 of 6)

```
                U.S. ARMY CORPS OF ENGINEERS - MEMPHIS DISTRICT
          HORN LAKE CREEK PHOTO CONTROL - GPS STOP & GO KINEMATIC SURVEY
A=  6378137.000 B=  6356752.314 X0=       0.000 Y0=       0.000 Z0=       0.000
RESID:

                    S T A T I S T I C S    S U M M A R Y

     Residual Critical Value Type                          Tau Max
     Residual Critical Value                                3.6624
     Convergence Criterion                                0.001000
     Final Iteration Counter Value                             2
     Confidence Level Used                                95.0000
     Number of Flagged Residuals                               30
     Estimated Variance Factor                             9.3212
     Number of Degrees of Freedom                              90

                  Chi-Square Test on the Variance Factor:

                  7.1012e+000  <  1.0000  <  1.2779e+001  ?

    !!!!!!!!!!!!!!!!!!!!!!!!   THE TEST FAILS   !!!!!!!!!!!!!!!!!!!!!!!!

RESID successfully completed.

GeoLab - V1.91S, (C) 1985/86/87/88/89 BitWise Ideas Inc. [103208976]  Page   31
```

Figure E-20. (Sheet 3 of 6)

U.S. ARMY CORPS OF ENGINEERS - MEMPHIS DISTRICT
HORN LAKE CREEK PHOTO CONTROL - GPS STOP & GO KINEMATIC SURVEY
A= 6378137.000 B= 6356752.314 X0= 0.000 Y0= 0.000 Z0= 0.000

ELLIPSE:

2-D AND 1-D STATION CONFIDENCE REGIONS (95.000 %):

IDENT.	MAJOR SEMI-AXIS	MINOR SEMI-AXIS	AZ(MAJ)	VERTICAL
4098	0.0037	0.0030	144.69	0.0080
4097	0.0112	0.0099	104.44	0.0232
5211	0.0087	0.0079	76.37	0.0166
5221	0.0230	0.0138	4.04	0.0539
5208	0.0355	0.0136	1.89	0.0596
5213	0.0079	0.0060	114.13	0.0117
2099	0.0129	0.0125	134.78	0.0006
5212	0.0229	0.0086	9.20	0.0990
5214	0.0140	0.0078	153.78	0.0407
5215	0.0076	0.0055	160.87	0.0217
5216	0.0056	0.0035	157.13	0.0196
5217	0.0153	0.0108	143.89	0.0345
5219	0.0168	0.0103	11.22	0.0323
5220	0.0098	0.0087	129.60	0.0006
7212	0.0103	0.0073	24.26	0.0219
5222	0.0069	0.0058	87.89	0.0139
5224	0.0151	0.0123	94.25	0.0323
5223	0.0079	0.0063	101.29	0.0176
5209	0.0075	0.0060	66.59	0.0114
5218	0.0124	0.0098	128.06	0.0201
5206	0.0117	0.0086	142.23	0.0264
5201	0.0090	0.0082	31.01	0.0006
5203	0.0116	0.0044	8.97	0.0542

GeoLab - V1.91S, (C) 1985/86/87/88/89 BitWise Ideas Inc. [103208976] Page 33

Figure E-20. (Sheet 4 of 6)

U.S. ARMY CORPS OF ENGINEERS - MEMPHIS DISTRICT
HORN LAKE CREEK PHOTO CONTROL - GPS STOP & GO KINEMATIC SURVEY
A= 6378137.000 B= 6356752.314 XO= 0.000 YO= 0.000 ZO= 0.000

ELLIPSE:

2-D AND 1-D RELATIVE STATION CONFIDENCE REGIONS (95.000 %):

FROM	TO	MAJ.SEMI	MIN.SEMI	AZ(MAJ)	VERTICAL	SPATIAL DIST.	PRECISION
4098	4097	0.0110	0.0098	99.29	0.0228	366.6974	30.134 PPM
4098	5211	0.0083	0.0072	72.51	0.0146	2912.1465	2.841 PPM
4098	5221	0.0232	0.0141	3.77	0.0543	4613.1048	5.031 PPM
4098	5208	0.0355	0.0133	1.94	0.0594	2733.5198	12.975 PPM
4098	2099	0.0127	0.0123	153.61	0.0080	2209.5932	5.731 PPM
4098	5212	0.0227	0.0081	9.40	0.0988	2184.0853	10.393 PPM
4098	5214	0.0141	0.0078	153.61	0.0401	1476.6279	9.515 PPM
4098	5215	0.0079	0.0058	158.62	0.0215	801.5977	9.882 PPM
4098	5216	0.0060	0.0039	154.93	0.0184	542.8319	11.054 PPM
4098	5217	0.0152	0.0106	143.88	0.0342	661.3901	22.922 PPM
4098	5219	0.0169	0.0105	11.04	0.0326	2891.5859	5.832 PPM
4098	5220	0.0093	0.0084	140.18	0.0080	2566.7382	3.642 PPM
4098	7212	0.0098	0.0064	26.24	0.0205	2016.1771	4.852 PPM
4098	5222	0.0070	0.0059	89.11	0.0142	4430.4221	1.583 PPM
4098	5224	0.0151	0.0123	94.26	0.0323	5477.8680	2.758 PPM
4098	5213	0.0076	0.0056	113.97	0.0113	1463.0774	5.189 PPM
4098	5223	0.0080	0.0065	102.62	0.0180	5905.2054	1.361 PPM
4098	5209	0.0079	0.0067	68.68	0.0131	2151.8379	3.652 PPM
4098	5218	0.0120	0.0094	127.14	0.0190	1886.0709	6.362 PPM
4098	5206	0.0119	0.0088	142.30	0.0269	3467.4963	3.430 PPM
4098	5203	0.0115	0.0041	9.24	0.0541	5895.6947	1.943 PPM
4098	5201	0.0092	0.0085	23.95	0.0080	6501.9478	1.419 PPM
4098	3095	0.0037	0.0030	144.69	0.0080	6444.1888	0.579 PPM
4097	3095	0.0112	0.0099	104.44	0.0232	6257.9628	1.785 PPM
3095	5211	0.0087	0.0079	76.37	0.0166	3561.8760	2.441 PPM
3095	5208	0.0355	0.0136	1.89	0.0596	3860.2179	9.207 PPM
3095	5221	0.0230	0.0138	4.04	0.0539	2049.7519	11.234 PPM
3095	5213	0.0079	0.0060	114.13	0.0117	5423.8080	1.464 PPM
3095	2099	0.0129	0.0125	134.78	0.0006	6228.3515	2.073 PPM
3095	5212	0.0229	0.0086	9.20	0.0990	4670.3246	4.898 PPM
3095	5214	0.0140	0.0078	153.78	0.0407	5123.7278	2.733 PPM
3095	5215	0.0076	0.0055	160.87	0.0217	6286.9777	1.207 PPM
3095	5216	0.0056	0.0035	157.13	0.0196	6093.8863	0.919 PPM
3095	5217	0.0153	0.0108	143.89	0.0345	6657.5098	2.301 PPM
3095	5219	0.0168	0.0103	11.22	0.0323	3553.0159	4.723 PPM
3095	5220	0.0098	0.0087	129.60	0.0006	4130.1976	2.364 PPM
3095	7212	0.0103	0.0073	24.26	0.0219	5986.6100	1.714 PPM
3095	5222	0.0069	0.0058	87.89	0.0139	2948.5823	2.341 PPM
3095	5224	0.0151	0.0123	94.25	0.0323	2553.4888	5.915 PPM
3095	5223	0.0079	0.0063	101.29	0.0176	1964.3997	4.007 PPM
3095	5209	0.0075	0.0060	66.59	0.0114	4497.4302	1.659 PPM
3095	5218	0.0124	0.0098	128.06	0.0201	4558.2364	2.717 PPM
3095	5206	0.0117	0.0086	142.23	0.0264	4289.4530	2.719 PPM
3095	5201	0.0090	0.0082	31.01	0.0006	7706.4127	1.165 PPM

GeoLab - V1.91S, (C) 1985/86/87/88/89 BitWise Ideas Inc. [103208976] Page 34

Figure E-20. (Sheet 5 of 6)

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                U.S. ARMY CORPS OF ENGINEERS - MEMPHIS DISTRICT
          HORN LAKE CREEK PHOTO CONTROL - GPS STOP & GO KINEMATIC SURVEY
A=  6378137.000 B=  6356752.314 XO=       0.000 YO=       0.000 ZO=       0.000
-------------------------------------------------------------------------------
ELLIPSE:

2-D AND 1-D RELATIVE STATION CONFIDENCE REGIONS ( 95.000 %):
-----------------------------------------------------------
FROM     TO       MAJ.SEMI MIN.SEMI AZ(MAJ) VERTICAL SPATIAL DIST.    PRECISION
-------- -------- -------- -------- ------- -------- ------------- ------------
3095     5203       0.0116   0.0044    8.97   0:0542     6734.0520    1.718 PPM

ELLIPSE successfully completed.
10:36:17 - Tuesday, October 09, 1990
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Figure E-20. (Sheet 6 of 6)

(2) 5 hr to set temporary photo control points and obtain visibility information at each site, 2-man crew.

(3) 2 hr to install two Type A monuments, 3-man crew.

(4) 5 hr to perform necessary Third-Order traverse and leveling, 4-man crew.

(5) 15 hr to collect static and stop-and-go GPS data, 5-man crew.

b. A conservative estimate of the field operations required by a 4-man party to 3D-position the 23 photo control points using conventional terrestrial methods was approximately 70 hr. The accuracies obtained from the final horizontal adjustment of the GPS data exceeded the requirements of the project. The accuracies obtained from the final vertical adjustment of the GPS data met the requirements.